NSF EPSCoR IN MONTANA

2011-2018

MONTANA NSF
EPSCoR

from the directors

As Montana NSF EPSCoR wraps up the current RII Track-1 project (2011-2018), we are excited to report exceptional science, education, and engagement outcomes. Project scientists made outstanding contributions to understanding climate-ecosystem linkages across diverse disciplines, the project established and supported the Montana Institute on Ecosystems (IoE), the state's flagship Institute for ecosystem and environmental research, and the IoE and partners completed and distributed the first ever Montana Climate Assessment. These achievements are significant contributions to the state of Montana, and produced impacts that sustain well beyond the completion of this project. The Montana Climate Assessment will continue to inform Montana's governing bodies and citizens, and the self-sustaining IoE will build on project outcomes and networks to facilitate new research across the state. The scientific focus of the project will endure and evolve as NSF EPSCoR RII Track-1 funding has leveraged nearly $50 million in new awards across the MUS.

Through the RII Track-1 project, Montana NSF EPSCoR made substantial investments in the scientific workforce and citizens of the state of Montana. The project contributed to over 20 new faculty hires at UM, MSU, and MTech, supported over 300 graduate and over 200 undergraduate students, and expanded inclusion of underrepresented groups in Science, Technology, Engineering, and Math (STEM). STEM development and research opportunity programs supported numerous Native American undergraduate and graduate students and contributed to professional development for faculty from Montana Tribal Colleges. The project developed an expansive outreach and inclusion network for advancing K-12 STEM education and public science outreach, including exhibits at spectrUM Discovery Area, science road shows, a unique Rough Cut Science speaker series, distinguished visiting scholars, and partnerships such as the Montana Girls STEM Collaborative, the Science Action Club, and Girls STEAM Ahead.

This publication highlights key projects and achievements but is only the tip of the iceberg of collaboration and productivity fostered by NSF EPSCoR in Montana. The dedication of Montana NSF EPSCoR researchers, students, staff and broader engagement team have continued the exceptional 40-year contribution of NSF EPSCoR investments in Montana's research and education capacity, and service to the state.

Ragan Callaway, Project Director

Todd Kipfer, Associate Project Director

Montana NSF EPSCoR

MONTANA NSF EPSCoR

Photo of Ragan Callaway by Kurt Wilson of the *Missoulian*

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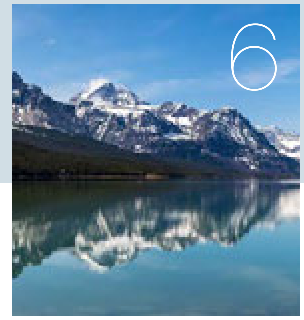

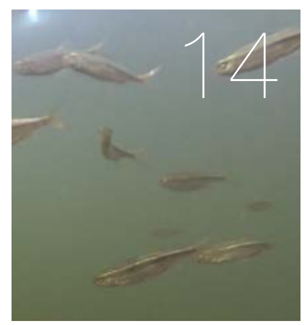

Montana NSF EPSCoR is a Montana University System program focused on stimulating sustainable improvements in Montana's R&D capacity and competitiveness in science and engineering research. We partner with the National Science Foundation EPSCoR (Established Program to Stimulate Competitive Research) program to develop and manage strategic projects funded by competitive NSF EPSCoR awards to the state.

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Montana | 39 Years as an EPSCoR State

Did you know Montana was one of the original five NSF EPSCoR states when the program was established by the National Science Foundation? EPSCoR was established in 1979 to help build science and technology infrastructure in states that, at that time, received the least federal research and development funding. The goal was to give broader geographic distribution of federal funding, which had been concentrated in a relatively few number of states. The experiment was a huge success, and Montana has received EPSCoR funding ever since. The program, which was initially centered at Montana State University in Bozeman, has included all Montana University System four-year institutions and tribal colleges at various times.

The following was written by Dr. Bob Swenson, emeritus vice president for research at Montana State University. This account is, in Dr. Swenson's words – "a memory, not a history." Swenson was at MSU at this critical juncture, and this documentation is appreciated.

The origins of NSF EPSCoR

In 1978 Congress authorized the "Experimental Program to Stimulate Competitive Research" (EPSCoR) in the National Science Foundation, seeking to disrupt a dichotomy between the "haves" and "have-not" states, in terms of federal research and development funds.

NSF soon identified the "least competitive" states based on a composite formula that measured federal research and development dollars on a per capita and per scientist basis. Montana received a planning grant and was one of five states to win a $3M EPSCoR Implementation Grant. Although excellent faculty were in the university system at that time, major changes were needed to meet NSF's requirements in order to provide time, facilities, instrumentation, and infrastructure for research, and to provide graduate student support. MSU's Research Park was established at that time.

Montana's original purpose, Montanans on a New Track for Science (MONTS), was led by Gary Strobel and was run as a "mini NSF." Faculty wrote proposals for MONTS funding, which were reviewed by a state-wide committee. Mentors, peer reviewers, and guest speakers were all part of this growing program.

Every NSF dollar required a state match, which required substantial dialog among university personnel, the Governor's Office, the Legislature, and the private sector MSU President at the time, Bill Tietz and Vice President John Jutila played key roles in acquiring these match dollars to hire new faculty and purchase major equipment. Additionally, a state science committee was formed; its role was to identify and support high priority research and technology.

After a decade of support provided by MONTS, the NSF program also evolved, which led to a MONTS II program with new expectations. The university and the Legislature collaborated, and in 1989, two highly significant bills were passed: HB 683 provided "Seed Capital" for research over 5 years of $7.5 million to be managed by the state science committee – the Montana Science and Technology Alliance (MSTA); and HB 233 returned 100% of IDC's (indirect costs for grants) to campus.

When Swenson became MSU's Vice President for Research in 1990, he stated that the "faculty were excited about and committed to the rapid growth of research opportunities due to a 'can do' spirit on campus." Swenson wrote to faculty, "…I have been overwhelmed… by the spirit and quality of the faculty… and the resulting vitality." The 90's saw a substantial increase in funding for research, including a commitment and capacity to hire excellent new faculty.

In the 1990's the NSF program added new dimensions with increased funding: emphasis on Science-Technology-Engineering-and Math (STEM) education and on technology transfer and economic development. Match dollars were available from the state.

Meanwhile, in the early 1990's, EPSCoR and EPSCoR-like programs were developed at NASA, NIH, DoD, DoE, and EPA. Using the very successful MONTS model created for NSF, MSU established similar models for each of the six new EPSCoR programs. By the end of the 90's, Montana was second only to Louisiana in winning EPSCoR awards.

- Dr. Bob Swenson
(1934-2016)

The Montana Institute on Ecosystems

On November 18, 2011 the Montana University System Board of Regents officially established the Montana Institute on Ecosystems (IoE). A grand experiment that is bringing together scientists from across the state, the IoE provides an umbrella framework to support integrated exploration of fundamental issues in ecosystem science, create new learning experiences to inspire and educate, and develop partnerships around relevant science topics to address the needs of Montana, the region, and the nation.

The IoE was established, in part, as a component of the 2011-18 NSF EPSCoR RII Track-1 award to the state. RII Track-1 investments in interdisciplinary ecosystems research, education, and outreach established a foundation of activity and opportunity. Founding co-directors Ric Hauer (UM) and Cathy Whitlock (MSU) worked with Todd Kipfer to establish administrative hubs on each campus and provided an interdisciplinary home for IoE affiliated faculty and students. This “Cat-Griz” partnership model proved highly successful, and the IoE expanded to include social-ecological systems research, an approach to understanding ecosystems that acknowledges people as a fundamental part of those systems, and development of new science networks around pressing ecosystem issues.

The IoE quickly grew into a model of collaborative success. New hires and joint-appointment faculty increased research capacity and competitiveness for Montana. IoE faculty leveraged NSF EPSCoR funding and published in leading journals such as *Science* and *Nature* and brought in new streams of competitive grant funding. The IoE developed an innovative partnership that resulted in the Montana Climate Assessment, a resource for the state and a model for how other states can meaningfully address complex topics such as climate variability and change. The IoE developed a nationally visible identity, and potential new students and faculty started to reach out to the IoE as a highly attractive component of the state’s higher education system.

Current IoE co-directors Bruce Maxwell (MSU) and Maury Valett (UM) have a vision to continue the IoE’s statewide integrating role around ecosystems sciences and develop new initiatives that address Montana needs and national priorities. Efforts are underway to develop new interdisciplinary opportunities for students, build upon the success of the Montana Climate Assessment, and expand scientific inquiry in areas such as coupled human and natural systems. The future for the IoE is bright indeed. •

The IoE developed a nationally visible identity, and potential new students and faculty started to reach out to the IoE as a highly attractive component of the state’s higher education system.

“Smokey Wild Goose Island Overlook”. Photographer: Jacob W. Frank from National Parks Service (NPS)

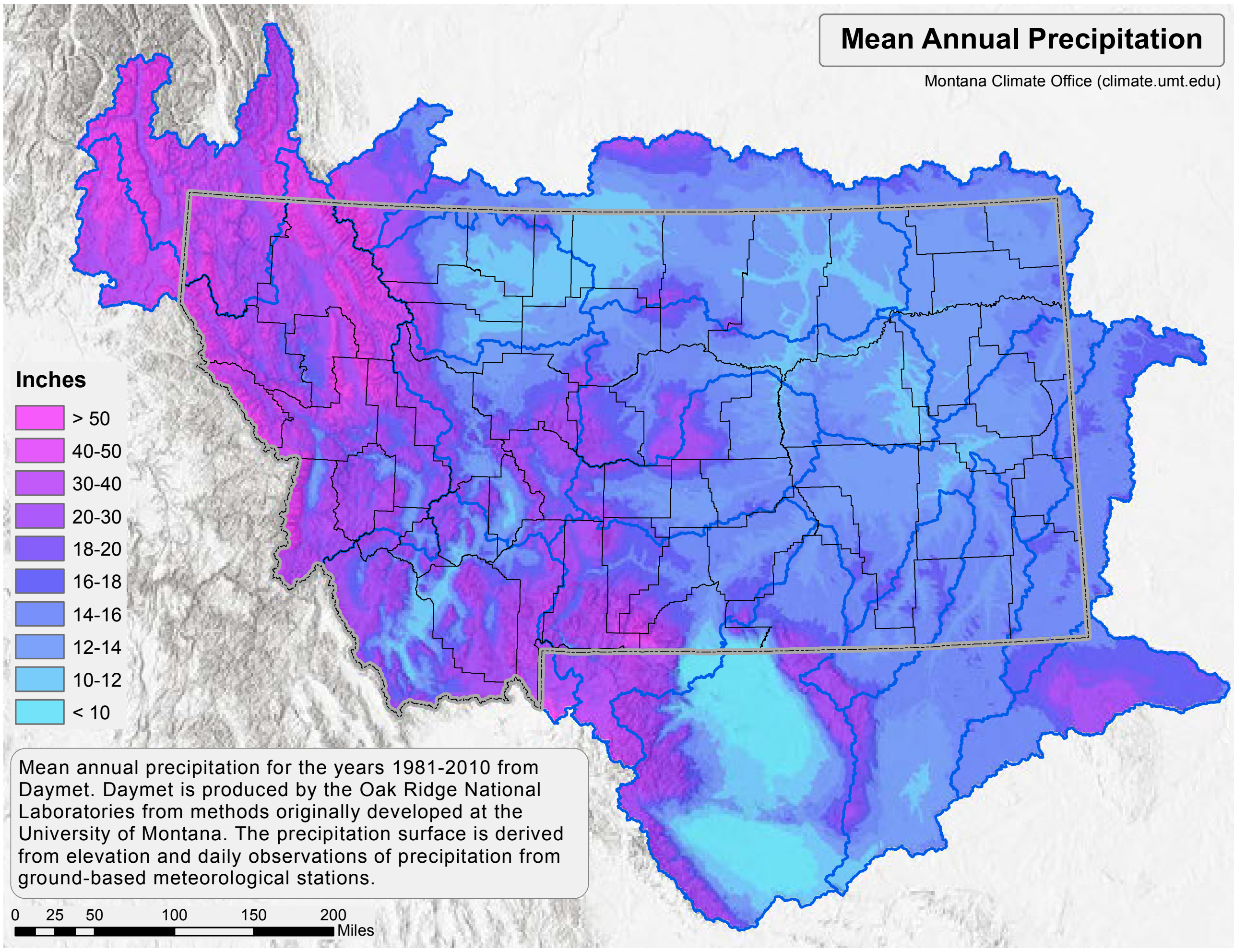
The Montana Climate Assessment

The MCA provides science-based information that may guide any actions needed to protect Montana's resources.

The NSF EPSCoR-funded Montana Climate Assessment aims to sustain a stakeholder-driven assessment of climate in Montana, and is the state's first such project. The MCA assesses potential impacts of climate change on the citizens of Montana, especially the farmers, ranchers, foresters, and water-users in the state. The emphasis is on understanding, "historical variability, current trends, and projections of future impacts as they related to topics of economic concern," according to the MCA guiding document, which is available online through Montana EPSCoR and the Institute on Ecosystems (http://montanaclimate.org). The MCA provides science-based information that functions as a guide on any actions needed to protect Montana's resources. The plan also informs relevant decision-making and adaptation planning for a changing Montana, and this initiative builds on broad interest for stakeholder-driven climate-change information that helps ensure a productive and rewarding future for all Montanans. So far the project involves 27 individuals from two Montana University System institutions, one state agency, and one non-profit – all of whom are heavily involved in the project. The group participated in over 40 exploratory listening sessions with stakeholders throughout the state who were asked to provide input about what climate information is needed and useful communication channels for delivering that information. The MCA team is also involved in outreach planning by collecting information about climate efforts across the state: agencies, NGOs, universities, tribes, K-12, and other stakeholder groups are all a part of the conversation. The EPSCoR outreach teams are also working on educational resource development to help teachers, students, and members of the public understand the MCA and current climate science research.

On May 1 of 2018 Dr. Cathy Whitlock, Montana State University ecologist and lead author of the 2017 Montana Climate Assessment, was elected as a member of the United States National Academy of Sciences. "Throughout my career I've been fortunate enough to have had inspiring and supportive mentors who encouraged me along the way, dynamic and engaging colleagues who have kept the science interesting and fun, and some of the brightest graduate students anywhere," Whitlock says. "Together, we've shared amazing moments of discovery, lots of challenging but unforgettable field experience, and many moments of laughter." •

Photo by Andrew Englehorn, National Parks Service (NPS)



Mean annual precipitation for the years 1981-2010 from Daymet. Daymet is produced by the Oak Ridge National Laboratories from methods originally developed at the University of Montana. The precipitation surface is derived from elevation and daily observations of precipitation from ground-based meteorological stations.

The Montana Climate Assessment synthesizes available climate data from different sources, focusing on Montana's water, forests, and agricultural regions. The precipitation information in this figure and from the Montana Climate Office are considered in the report. The report is available in it's entirety at http://montanaclimate.org/

Ecosystem Researcher Investigates Honey Bee Health

The food we most associate with honey bees is the sweet gooey stuff we put on our toast and in our tea, but bees play a much larger role in ecosystems around the world. Bees are essential pollinators of many agricultural crops, and if a honey bee colony collapses, nearby crops are at risk.

Bee colonies have experienced an increase in losses in recent years, and just why these colonies are in decline is a research focus for IoE Faculty Fellow Michelle Flenniken. Her work is one component of a comprehensive Montana EPSCoR research agenda to understand linkages between microbial systems and larger scaled ecological processes under a variable and changing climate. The plight of honey bees is an excellent opportunity to connect research on an important ecological process – pollination – to food production, a vital human need and a significant economic driver for Montana.

Flenniken, a research professor in the MSU Department of Plant Sciences and Plant Pathology, focuses on honey bee health. She studies the molecular mechanisms underlying host-pathogen interactions in agriculturally important systems. Flenniken received research support as part of the Montana EPSCoR RII Track-1 project. Her multidisciplinary research spans microbiology, virology, ecology, and agriculture and requires that she work closely with honey bee keepers across the country.

Flenniken knows that honey bee colony deaths are associated with higher pathogen levels, but the specific pathogens, hosts, and environmental factors that drive these declines remain unknown. Her work is ongoing, including studies of honey bee antiviral defense, honey bee pathogen monitoring, pathogenesis of the recently discovered Lake Sinai viruses, understanding honey bee immune system response, and examining the role and agrochemicals. She hypothesizes that the impact of pathogens on honey bee colony health is governed by additional factors, including host responses and the microbial context of infection. Using cutting-edge research methods, she examines agrochemical exposure on chemical abundance. A detailed molecular analysis is used to identify the combinations of genes, microbes, and metabolites that augment and lessen the effects of pathogenic infections.

An increased understanding of these factors may lead to strategies that can help bee keepers mitigate honey bee colony losses. And, discoveries of honey bee immune genes and pathways may reveal evolutionarily conserved innate immune pathways in other social organisms. In other words, what she learns about honey bees can help us better understand other complex ecological processes related to agricultural systems.

This not only directly impacts Montana's agricultural producers, but will also help to inform how ecosystems operate across landscapes and down to micro-scales. As top-down drivers such as climate change affect ecological processes, a better understanding of these systems helps predict ecosystem vulnerabilities to change and identify best practices to mitigate and adapt. •

Photo by Michelle Flennekin

New Discovery in Lichens Overturns 150 Years of Science

Contrary to 150 years of belief in lichen as product symbiosis, a mutually beneficial relationship between fungi and algae, two University of Montana researchers discovered a third partner exists in the most successful lichens – their own second fungus hiding in plain sight.

Toby Spribille and John McCutcheons' pioneering discovery made headlines in *The Washington Post* and *The Atlantic* magazine, and was featured on the cover of *Science*.

It started when the two scientists noticed something that did not add up. The lichen *Bryoria fremontii*, a brown edible horsehair lichen, and the *Bryoria tortuosa*, a yellowish inedible and poisonous horsehair lichen have the same genetic makeup when looking at the symbiosis between the alga and fungus. They contain the exact same species of alga and exact same species of fungus, but appear totally different, grow in different regions of the world, and one is toxic while the other is not. In their final analysis of the two lichens they noticed a distinct pattern of a second fungus, which had previously been eliminated as a contaminant. The two scientists sought to find if the genes of the new fungus correlated with the toxic differences of the two lichens.

“There it was,” Spribille recalls. “There was a clear pattern. It was all in the second fungus. Whenever the lichen produced this toxin, it had 12 times more of this additional fungus. This was the eureka moment if there was one. It’s not a contaminant. Most lichens have their own second fungus. We’re pulling an organism out of lichens, with almost 100 percent success, that nobody knew existed.”

“We are giving ourselves permission to go out into nature and look again,” McCutcheon says. “After this work, the world looks different to me now, and that’s pretty exciting.” •

Photos by Tom Wheeler, tomwheelerphotography.com.

Interview by Marina Richie, Vision Magazine, University of Montana.

Fort Peck Buffalo Project Examines the Impact of Yellowstone Bison Re-introduction to the Assiniboine and Sioux Tribes

The American bison once inhabited the plains of Montana and the American west in herds of millions. Animals and humans alike depended on this massive animal, weighing in at 1,000 – 2,000 lbs. Many of the Nakoda and Dakota people of the Fort Peck Reservation Tribes consider bison to be as important as people; to them the bison are *Buffalo People*. Buffalo, the name preferred by Indigenous people, are considered central to community, culture, and health. They offer food, ceremonial objects, and a way of life through spiritual, place-based, and ancestral connections.

In a community based participatory research project, The Fort Peck Buffalo Project, collaborators from three different institutions – Fort Peck Community College (FPCC), Montana State University (MSU), and the World Wildlife Foundation (WWF) – collaborated to understand, and enhance, the impact of re-introducing buffalo to the Fort Peck Indian Reservation. In 2000, 100 bison were transferred to Fort Peck from the Fort Belknap reservation, ending a 130-year absence of this native mammal. In 2012, a transfer of 63 Yellowstone bison to the Assiniboine and Sioux Tribes of Fort Peck began a separate "cultural herd," i.e. of "heritage" buffalo that had never been genetically mixed with cattle. In 2014 an additional 139 Yellowstone bison arrived at Fort Peck, and the cultural herd now numbers over 300 (about the carrying capacity of the current dedicated ranch land). The other herd, now of similar size, is referred to as the "business herd" and sales of the hunts used to cull this herd (as necessary to sustain the land-base) help pay for the overall Fort Peck Tribes Buffalo Program.

Starting in 2013, FPCC and MSU collaborated in response to a question raised by a group of Fort Peck elders – how does and how can the buffalo's presence on the reservation enhance overall community and cultural well-being? This collaboration, supported in part through funding from Montana NSF EPSCoR, resulted in diverse responses to this question, including: (1) a qualitative research project investigating the impact of the return of the buffalo to Fort Peck on individual and community health and well-being, (2) a community educational outreach event called the Buffalo People Gather and Unite Summit that was held during Native American Week in 2015, (3) an oral history research

project documenting the recent history of buffalo restoration on the Fort Peck reservation, and (4) a joint project with the World Wildlife Fund to understand what the people of Fort Peck want from their buffalo herds' management, how the management can be improved, and attitudes toward wildlife conservation in general. Contributing researchers included Roxann Smith (Fort Peck Community College), Robert McAnally (Fort Peck Community College), Lois Red Elk (Fort Peck Community College), Elizabeth Bird (Montana State University), Elizabeth Rink (Montana State University), Dennis Jorgensen (World Wildlife Fund), and Julia Haggerty (Montana State University).

Through the projects listed above, designed to stimulate community outreach and engagement and examine the history of bison restoration advocacy by the Fort Peck Tribes, researchers investigated the deep connection of the Fort Peck Tribes to the Buffalo People, or Tatanga/ Tatanka Oyate. Findings demonstrated that pride in the buffalo's return is a source of resilience, and the people's deep spiritual commitment to the buffalo were central to the resilience that made the restoration process possible. Other findings reveal that powerful key actors' capacity to collaborate with external partners was also critical to achieving success. New actors emerged in the course of the Buffalo Project, most notably the grassroots organizing initiative called the Pté Group (Pté meaning female buffalo in both Assiniboine and Sioux). The informal Pté Group, formed initially to organize the Summit and other educational activities, has been advancing public knowledge, interest and commitment to the buffalo through teacher institutes, and new collaborations.

The Fort Peck Buffalo Project has inspired new initiatives, aimed at further enhancing the connectedness of buffalo and people, and the impacts of the cultural herd. In 2016 MSU Architecture faculty member Michael Everts and his students helped community leaders design a walking trail with interactive art installations on the cultural herd ranch. Funds have been raised and the collaborative work is proceeding on four "story poles." In 2017 the Montana Community Foundation provided funds for a Fort Peck Head Start buffalo curriculum. The curriculum shell is being designed by MSU/HHD faculty Christine Lux and student, and an initial training/dialogue with the Fort Peck Head Start teachers was held in fall 2018. Additionally, in the past two years, the Fort Peck Buffalo Program, with help from WWF, has dramatically enhanced the people's access to buffalo meat and products (pursuant to findings of the survey, #4 above), and increasingly the two buffalo herds are serving as an engine of local economic development.

The driving question of the Fort Peck Buffalo Project will continue to be studied through a USDA grant to FPCC (with MSU collaborators Elizabeth Bird, Michelle Grocke and Brianna Routh) that will re-engage the impact question through focus groups and strategic planning with Tribal programs and departments. During the 2015 Summit, the Fort Peck Tribes reaffirmed their commitment to the InterTribal Buffalo Treaty, but the treaty has received scant attention across the reservation and across Tribal programs. The new project will help Tribal programs reflect on and strategize about how they can actively participate in some aspect of treaty implementation, and thereby further enhance the buffalo herds' impacts on community well-being.

Throughout these research and engagement processes the team has found great enthusiasm from the people of Fort Peck for the restoration of the buffalo, and a shared feeling of connection and kindred-spirit toward the buffalo. The re-introduction, and the community-building activities that have followed, have indeed been catalysts for enhanced social capital and improved well-being – the buffalo are increasingly a unifying and resilience-enhancing feature of the Fort Peck socioeconomic, cultural and ecological landscape. Connections of the Fort Peck peoples with the Buffalo People are embedded in the past and the future of the Fork Peck Tribes.

Photos by Alexis Bonogofsky

Montana Girls STEM Collaborative: An NSF EPSCoR Success Story!

From young citizen scientists in Sidney to video game-developing girls in Great Falls to budding computer coders in Butte, the Montana Girls STEM Collaborative has supported more than 1,000 youth and hundreds of adults since its launch under Montana NSF EPSCoR in 2012.

The Montana Girls STEM Collaborative – a state chapter of the National Girls Collaborative Project – began in 2012 as an outreach program of Montana NSF EPSCoR. The program is designed to share STEM programs and resources while building collaborations that engage and inspire girls and youth from under-represented audiences. The Collaborative's original leaders were Martha Peters, then with the Montana NSF EPSCoR office; Suzi Taylor at Montana State University-Bozeman; and Holly Truitt at the University of Montana-Missoula. An advisory board is comprised of volunteers from across the state, including Nancy Schweitzer (previously the First Lady of Montana)) and later First Lady Lisa Bullock as well as partners from industry, government and non-profits.

Just like EPSCoR, the Collaborative's goal is to build an infrastructure that is inclusive, effective, and sustainable. In its six-year existence, Montana Girls STEM Collaborative has done just that, drawing upon national resources offered to Montana and supporting in-state partnerships that benefit girls and boys alike.

A long-time partner is the Women's Foundation of Montana, which promotes economic independence for girls and women through advocacy, research and education. WFM has supported several Montana Girls STEM Collaborative initiatives, including Science Action Club (a citizen science curriculum for middle school youth); professional development for educators and STEM champions; and the service of an AmeriCorps VISTA member, who conducted trainings for youth mentors with Thrive, a STEM table at Alive at Five in Helena and nanotechnology outreach at MSU-Bozeman's Family and Graduate Housing complex.

The Montana Girls STEM Collaborative has also:

- Brought nearly $100,000 worth of national STEM outreach programs to Montana, including Cornell Lab of Ornithology's Habitat Connections, Techbridge's Role Models Matter, the California Academy of Sciences' Science Action Club, the University of Chicago's CryptoClub, and NASA's Girls STEAM Ahead.
- Hosted annual collaboration forums in Missoula, Billings, Helena, Great Falls and Bozeman. These meetings for adults who serve girls are designed to share resources and exemplary practices while building collaborations amongst individuals and organizations.
- Partnered with Science on Screen in Bozeman to host a showing of Dream Big, an IMAX movie that reached 800 people (including many girls and young women) with engineering inspiration and hands-on activities.

In addition, the Collaborative has presented its work at meetings of the Montana Afterschool Alliance, the Montana Education Association and Montana Library Association. The Montana Girls STEM Collaborative has been showcased at the national NSF EPSCoR meeting in Missoula (2017) and at the NSF INCLUDES Summit in Washington, D.C. (2018).

For more information about the Montana Girls STEM Collaborative, visit ngcproject.org/montana or follow the Collaborative on Facebook (facebook.com/MontanaGirlsSTEM) or Twitter (twitter.com/MTGirlsSTEM). The Collaborative offers a free quarterly e-newsletter featuring STEM grants, events and opportunities. Sign up at **http://bit.ly/mgsc-newsletter.** •

Colin Quinn (second from left, holding kite) **is an Earth Sciences student who participated in NSF EPSCoR outreach programs while a student in Communicating Ecosystem Science in Spring 2017, then went on to volunteer for a NASA-funded educational outreach program called Aerokats and Rovers Education Network.**

Montana NSF EPSCoR Develops Innovative Science Communications Program for Graduate Students

From the National Science Foundation to industry, organizations increasingly value science communications skills for both scientists and students, including opportunities for direct engagement with the public. But many STEM students don't have time for a semester-long science communications and outreach course, and many institutions struggle to offer one.

To prepare early-career scientists for public outreach, the Montana NSF EPSCoR outreach team at Montana State University developed a six-week, non-credit certificate for graduate students working with NSF EPSCoR-funded researchers. In addition to teaching valuable career-related skills, the program engaged participants in hands-on outreach directly tied to grant funding and prepared students to write broader impacts for future proposals.

Communicating Ecosystem Science was piloted in Fall 2015 and full cohorts were recruited in Spring 2016 and Spring 2017.

The course included standard science communications topics like writing, social media and data visualization but placed extra emphasis on broader impacts strategies and evaluation. All students were required to participate in a Montana NSF EPSCoR outreach project involving direct contact with the public, thus building their professional experience while contributing to public understanding of NSF research.

The students, most of whom had no previous outreach training, reached more than 1,000 people through youth programs like Science Action Club and NanoDays; climate change stakeholder meetings; Teen Science Cafes; and other activities.

100% of participants agreed or strongly agreed the program increased their ability in science communications, motivation for science communications, and career skills. Students said they especially valued participating in university outreach projects and working alongside MSU's professional outreach staff. •

Outreach events and activities of Communicating Ecosystem Science students

- **NanoDays/MicroDays**
- **MSU Explore: Earth and Space Science Camp**
- **Red Ants Pants Music Festival science outreach tent**
- **Sustainabilibash**
- **Science Action Club – citizen science program**
- **Hour of Enrichment at Irving Elementary School**
- **MSU Family Science Night**
- **Expanding Your Horizons Day of STEM for girls**
- **Peaks & Potentials summer camp**
- **Climate Assessment Listening Session**
- **Teen Science Café**

New Fish Eye View Exhibit at spectrUM Discovery Area

Over 700 elementary students "ooh-ed," "aah-ed" and "wow-ed" at a large-screen, 3D view of a "Fish Eye's View" video experience at the Montana Wildlife Film Festival at the University of Montana on April 18th, 2018. The students saw a portion of the 3D video with underwater footage of the Upper Clark Fork River with nearly 20 westslope cutthroat trout. All the while, they were learning about the underwater habitats and stresses that come with a moving and ever changing ecosystem. At the University of Montana spectrUM Discovery Area, visitors can view this same footage while wearing virtual reality goggles for a truly submersive experience.

The Montana Institute on Ecosystems, a product of Montana NSF EPSCoR, spectrUM, UM's Department of Media Arts, and the Clark Fork Coalition collaborated on this effort to collect immersive underwater 3D imagery as a tool for teaching conservation. Supported in part by the National Science Foundation EPSCoR Cooperative Agreement OIA-1443108 and EPS-1101342 and leveraging healthy cross-disciplinary partnerships at UM and ongoing research by the Valett Lab and the Clark Fork Coalition, this footage became the Fish Eye experience.

The collective contributions of these partners, the spectrUM Discovery Area (exhibit design, science education and STEM achievement), the school of media arts (digital media production and editing), and the Clark Fork Coalition (science communication and developing watershed literacy) pulled together to tackle complex challenges of integrating cutting edge videography and digital media production with the stories and subjects of scientific research.

To date, the prototype Fish Eye View experience has reached over 1,100 people in a variety of formats: an in-museum experience with in-depth educational content, a shorter version for field trip groups with lighter content, and a version similar to snorkeling, with a 3D underwater view. Last summer, spectrUM embedded the experience in a gaming chair that senses head movements. •

The spectrUM Discovery Area, a hands-on science center, an "EPSCoR baby" according to director Holly Truitt, underwent a change in location in order to accommodate the rapidly growing audience of inspired young Montanans. In 2013 spectrUM opened its doors in downtown Missoula to an annual 39,000 visitors. In the fall of 2017 spectrUM moved to a larger space to accommodate the over 200,000 people they reach each year with their exhibits at the spectrUM Discovery Area, as well as their mobile science Makers Truck. Exhibits include a flight simulator, erosion table, and 3-D printer.

As a vital part of the University of Montana and Missoula community, the EPSCoR-leveraged but now sustainable spectrUM inspires a culture of learning, discovery, and inclusivity for all Montanans, with the ultimate goal of motivating K-12 students to pursue higher education and possibly careers in STEM. Dedicated to closing achievement gaps in science, technology, engineering, and mathematics (STEM), spectrUM continues to grow as they make plans to open yet another two locations attached to the new Missoula Food Bank, as well as the new Missoula Public Library.

spectrUM also played host to the welcome reception for 25th NSF EPSCoR National Conference, which took place in November of 2017.

Only recently has there been a call for understanding the social dimensions of restoration.

Building River Restoration Capacity

In the summer of 2014, natural and social scientists at the University of Montana launched a collaborative project focused on understanding the factors that influence river restoration. Through the use of Systems Theory, the team critically examined ecological, social, and business dimensions of restoration in the context of the Clark Fork River in Montana. This comprehensive and interdisciplinary research identified drivers of restoration success that contribute new knowledge to our understanding of restoration capacity.

Ecological restoration – assisting in the recovery of degraded, damaged, or destroyed ecosystems – has become a dominant natural resource management effort. The majority of the science associated with restoration has been ecologically focused. Only recently has there been a call for understanding the social dimensions of restoration. Montana EPSCoR funded an exploratory study based on 40 field-based interviews with stakeholders throughout the Clark Fork River corridor. Based on these interviews, three key foundational elements of social-ecological system were identified: complexity, information capital, and collaborative communication. These findings contributed to an integrated systems approach to restoration approaches that combined ecological and sociological drivers of restoration success to build a foundation for 'restorative capacity.' •

Dissolved Oxygen Modeling of Macrophyte-rich Streams

Raja Nagisetty (Montana Tech), along with Kyle Flynn (Environmental Engineer/Modeler, MT DEQ) and Dylan Uecker (Graduated from Montana Tech in 2016, currently working for Carollo Engineers) developed a methodology to incorporate the effects of macrophytes on dissolved oxygen in surface water quality modeling. Silver Bow Creek, a small urbanized stream in Western Montana, is listed as 'Impaired Waters' under the Clean Water Act. The Butte Metro Waste Water Treatment Plant (WWTP) underwent a significant upgrade during 2015-2016. Before the upgrade, Butte Metro WWTP was a major contributor of excess nutrients into Silver Bow Creek. The section downstream of the plant (from Butte to Rocker, MT) is highly eutrophited and contains large masses of macrophytes. As a result, there are huge dissolved oxygen diel swings and hypoxic conditions.

MT NSF EPSCoR funding to Raja Nagisetty has supported extensive water quality characterization of a 6km stretch of Silver Bow Creek in Butte, MT, during the summer of 2015 and 2016. The researchers used a mass balance approach to incorporate the effects of macrophytes on dissolved oxygen in a water quality model used to represent a well-mixed stream channel. Field experiments were conducted to estimate the magnitude of dissolved oxygen equivalency of macrophytes. The calibrated model adequately predicted the macrophytes effect on dissolved oxygen pre- and post- WWTP upgrade. The study provides significant insights into dissolved oxygen modeling of macrophyte-rich streams and water quality improvements from WWTP upgrades. •

Jencso and Hu: UM–MSU Collaboration

One goal of the Montana NSF EPSCoR Track-1 research project was to increase multi-institutional research collaboration. Through creation of the statewide Institute on Ecosystems and innovation programs to engage faculty across disciplines, departments, and institutions, such as the Rough Cut Science Series, the Mentoring Program for Interdisciplinary Initiative, the Science Summit, and the popular affiliate program, many multi-institutional research collaborations have been established. One example of collaborative success involves two early career faculty, Dr. Jia Hu at Montana State University and Dr. Kelsey Jensco at the University of Montana. Hu, a plant ecophysiologist, was an EPSCoR-supported hire and held a joint appointment with MSU's Ecology Department and the IoE. Jensco, a watershed hydrologist and climate scientist was hired to lead the Montana Climate Office. Through the IoE, Hu and Jensco met and hatched an idea for a research partnership. With seed funding from NSF EPSCoR Track-1 and the IoE, the two started working together at the Lubrecht Experimental Forest in western Montana to understand how declining winter snowpack and increased deposition of nitrogen affect the productivity of forests in the western United States. In recent decades winter snowpack has declined, while anthropogenic nitrogen has increased. Particularly in our complex mountain landscapes, these changes impact the hydrology and geochemistry of snow-dominated montane forests in complex ways. Hu and Jensco want to understand how these factors combine to influence forest productivity. They established research sites with extensive sensor networks to collect necessary data. Based on initial data collection, they began writing proposals for additional funding. Montana NSF EPSCoR Director Ray Callaway put this type of seed funding into perspective: "Leverage, leverage, leverage. Montana NSF EPSCoR seeds new ideas that can be competitive for new research grants, building Montana's research enterprise." The first success of this partnership was a grant from USDA – also including co-PI Dr. Yuriko Yano –that funds expansion of their interdisciplinary study. Their work helped sustainably manage agroecosystems in response to changing environmental conditions. All three researchers are also very committed to public outreach and mentoring university students. •

Collaboration Continues as MtnSEON Network Promotes SES

The Mountain Social Ecological Observatory Network (MtnSEON) is a research network with the goal of improving social and ecological resilience and sustainability for complex mountain landscapes in the Northern Rockies region and neighboring areas. Funded by the NSF Research Coordination Network program, MtnSEON emphasizes social-ecological systems (SES) approaches, bringing together social and ecological scientists to collaboratively understand these coupled human-natural systems. Led by Jim Gosz at the University of Idaho and an executive committee that includes Montana EPSCoR Director Ray Callaway, MtnSEON facilitates, coordinates, integrates and synthesizes existing research; designs new research and education projects; and creates partnerships. Nine working groups cover an impressive range of topics, from large carnivores to riverscapes. One of the growing partnerships is the Social Ecological Systems Training and Education Program. SESTEP aims to provide professional certification and graduate-level accreditation of “SES (social-ecological systems) in practice” for land and natural resource practitioners, managers, and decision-makers. The 10-week program included two weeks of in-person training and eight weeks of virtual course work. Participants learned SES theory, communication and collaboration skills of working across disciplines, regulatory considerations, and a process to identify and analyze the SES system in which they work. MtnSEON is an ideal partner for Montana NSF EPSCoR, which has established SES science as a priority for research and education through new social science faculty hires and statewide programs such as the IoE SES Initiative. Montana NSF EPSCoR and the IoE worked with MtnSEON to address a fundamental question: How can we reduce the vulnerability, improve resilience, and support sustainability of natural and human systems in complex mountain landscapes? Answering that question requires new collaborative research and education that crosses a diverse spectrum of disciplines and perspectives. •

The Interdisciplinary Collaborative Network

For specialists in any field, the ability to share expertise and knowledge is key to increasing efficiency and enhancing outcomes. Yet, sharing information and resources across a large and geographically dispersed research community can be challenging. The Interdisciplinary Collaborative Network (ICN) was founded to tackle this challenge. University of Montana graduate student Mandy Slate rallied her colleagues to come together and develop a way to share resources, expertise, and interests. A second year PhD student in Organismal Biology and Ecology, Slate realized that effective scientific research involves collaboration across disciplines, which often requires a nudge to get started. The ICN provides a mechanism through which individuals in disparate fields or geographic locales may easily find opportunities to contribute to research on the same system or concept. ICN connects researchers from varying professional levels, universities, and disciplines with the Montana University System, with the goal of integrating research and disciplines across the state. According to Slate, it has already made a difference. “The enthusiasm with which people are encountering the project as a whole has been inspiring. By facilitating new relationships we are fostering opportunities for collaborative research to develop organically.” •

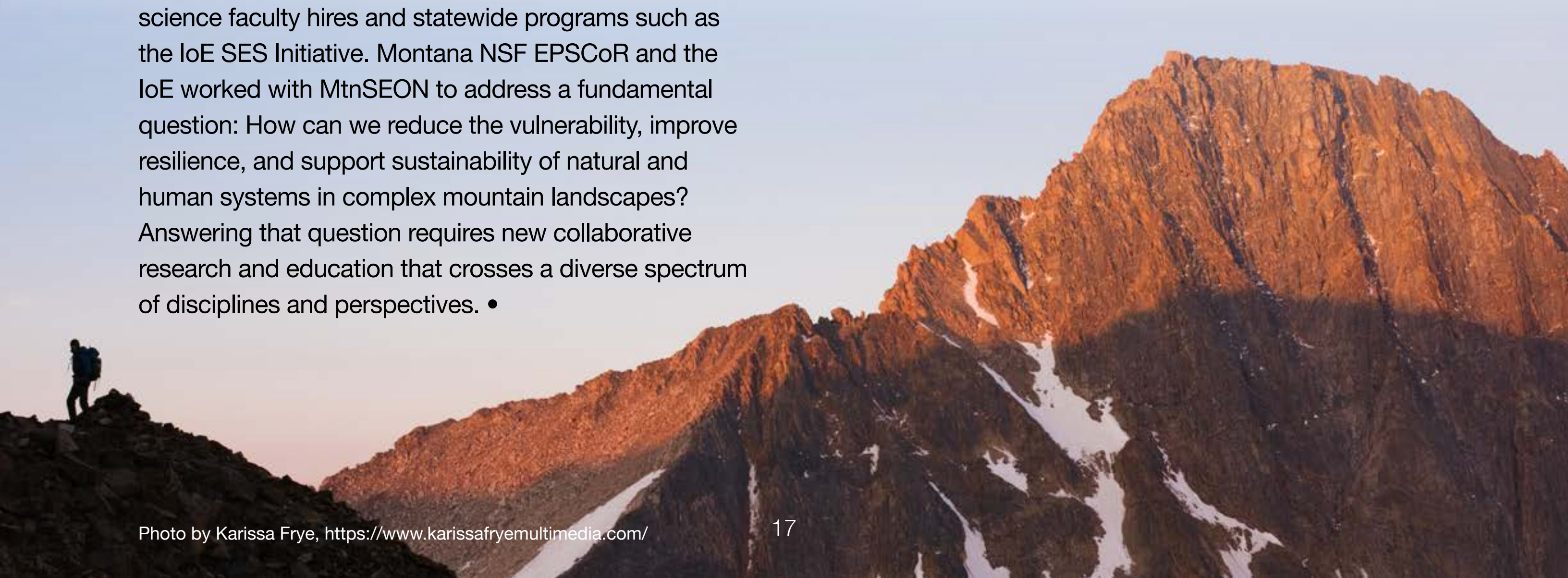


Photo by Karissa Frye, https://www.karissafryemultimedia.com/

Evolutionary Genomics of Adaptation Symposium

The first annual symposium on the Evolutionary Genomics of Adaptation was held on June 1-3, 2018 at the Flathead Lake Biological Station near Polson Montana. This interdisciplinary symposium is linked to the recently established UNVEIL network (www.unveilnework.org), funded by an NSF EPSCoR RII Track-2 grant (OIA-1736249) by the University of Montana (PI Z. Cheviron, co-PIs J. Good, L. Fishman, L. S. Mills) and the University of Nebraska, Lincoln. This aim of this research and training network is to both advance the science of genome-to-phenome connections in natural populations, and use these insights to inform effective conservation and resource management strategies and the use of emerging biotechnologies in conservation biology. This year's symposium featured talks by four distinguished keynote speakers: Dr. Sally Aitkin (University of British Columbia), Dr. Benjamin Blackman (UC Berkeley), Dr. Nancy Chen (University of Rochester), and Dr. Mike Shapiro (University of Utah). Invited presentations featured cutting-edge studies in population genomics, environmental adaptation, ecological genetics, quantitative genetics, systems genetics, genetic engineering and conservation genomics. In addition to a full scientific program, the symposium also featured a half-day interdisciplinary panel discussion and workshop led by UM Professor Dane Scott on the ethics of genomic interventions for solving conservation challenges. •

Further details can be found at:
https://www.unveilnetwork.org/connect/

Flathead Lake photo by Todd Goodrich.

NSF EPSCoR RII Track-1

BY THE NUMBERS

321
Publications

$47M
Proposals Awarded

28
New Faculty Hires
(over all years)

STUDENTS AND POSTDOCS SUPPORTED ON PROJECT

YEAR	UNDERGRADUATE	GRADUATE	POSTDOCS
Y1	22	45	0
Y2	22	48	6
Y3	38	48	7
Y4	36	48	6
Y5	33	60	6
NCE	60	89	12
TOTAL	**211**	**338**	**37**

NSF EPSCoR RII Track-2 and Track-4 Projects in Montana 2011-2018

RII Track-2 FEC: *Neural Basis of Attention*; Award No. 1632738; 2016-2020
PI: Peter Tse (Dartmouth); Co-PIs: **Charles Gray (MSU)**; Gideon Caplovitz; (UNR); David Scheinberg (Brown)

RII Track-2 FEC: *Water, Agriculture, Food, Energy, Research Nexus* (WAFERx); Award No. 1632810; 2016-2020
PI: **Paul Stoy (MSU)**; Co-PIs: David Swanson (USD); **Selena Ahmed (MSU)**; Meghann Jarchow (USD); Benjamin Rashford; (UW); Benjamin Poulter (NASA)

RII Track-2 FEC: *Building Genome-to-Phenome Infrastructure for Regulating Methane in Deep and Extreme Environments* (BuG ReMeDEE); Award No. 1736255; 2017-2021
PI: Rajesh Sani (SDSMT); Co-PIs: Lee Krumholz (OU); **Robin Gerlach (MSU)**; Venkata Gadhamshetty (SDSMT); Saurabh Dhiman (SDSMT); Kevin Hadley (SDSMT)

RII Track-2 FEC: *UNVEIL – Using Natural Variation to Educate, Innovate, and Lead*; Award No. 1736249; 2017-2021
PI: **Zac Cheviron (UM)**; Co-PIs: **Lila Fishman (UM)**; **Jeffrey Good (UM)**; Jay Storz (UNL); Kristi Montooth (UNL)

RII Track-4: *Strengthening Structural Biology Research with Single Particle Cryo-Electronic Microscopy* (cryo-EM); Award No. 1738547; 2017- 2019
PI: **Tung-Chung Mou (UM)**

RII Track-4: *Governing Social-Ecological Transformation across Working Landscapes*; Award No. 1738857; 2017-2019
PI: **Brian Chaffin (UM)**

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Photo by Tim Rains, National Park Service (NPS)