MONTANA NSF EPSCoR

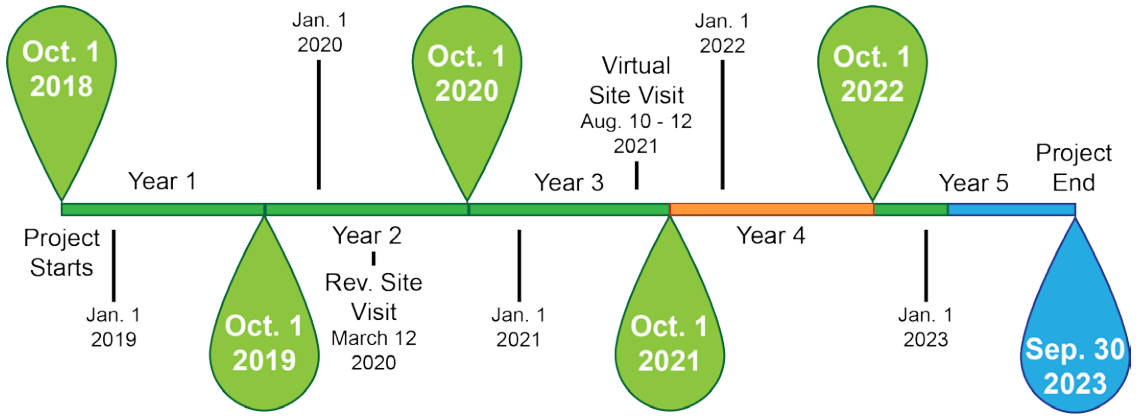
NEWSLETTER

CREWS YEAR 4 HIGHLIGHTS 2022

A CREWS researcher records water sample data in the Judith River Watershed as part of the team's summer fieldwork campaign in Year 4. *Photo credit: Rachel Anderson.*

YEAR 4 HIGHLIGHTS

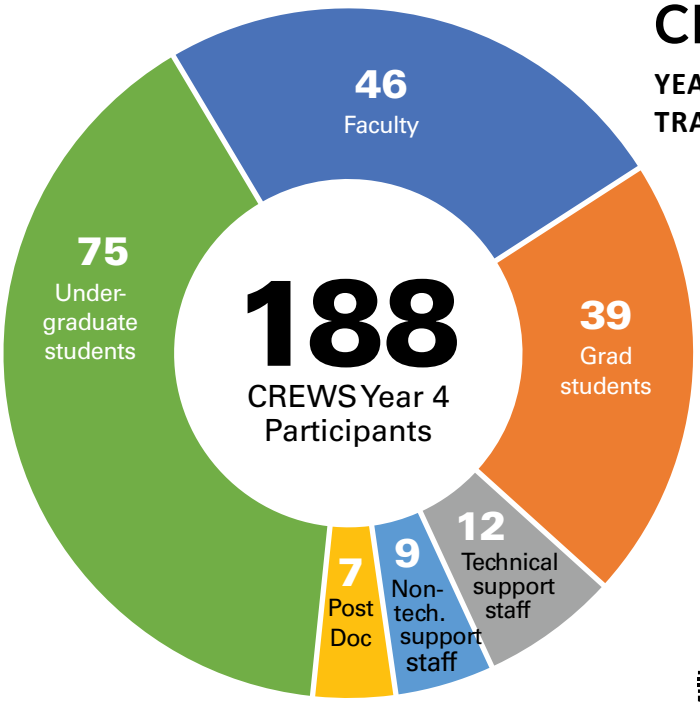
This Special Issue of the Montana NSF EPSCoR newsletter provides a summary of the Year 4 activities and progress for the RII Track-1 Consortium for Research on Environmental Water Systems (CREWS) project. CREWS, supported by the National Science Foundation under Award OIA-1757351, is a five-year $20M project that explores how nutrients and contaminants affect stream and ground water quality and local communities that rely on clean water. The project focuses on three Montana landscapes where water and economy are inextricably linked and creates opportunities in workforce development, innovation, and entrepreneurship. See the timeline below for an overview of where activities described in this newsletter sit on the project timeline (highlighted below) as well as other major project milestones and dates.



Timeline of the Montana NSF EPSCoR RII Track-1 CREWS project illustrating the major dates and milestones. This Special Issue newsletter highlights activities that occurred in Year 4 of the project, noted in orange on the timeline.

CREWS BY THE NUMBERS

YEAR 4 OUTCOMES OF MONTANA'S NSF EPSCOR RII TRACK-1 PROJECT



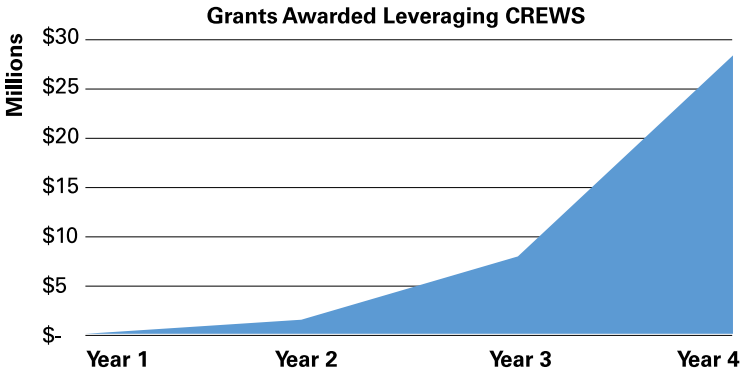
$1.4 MILLION IN CO-FUNDING - Total NSF EPSCoR co-funding awarded to Montana in Year 4

106 PUBLICATIONS – Cumulative total number of publications released by CREWS researchers by the end of Year 4

65 PARTNERS AND COLLABORATORS – Total number of CREWS external partners and collaborating institutions in Year 4. For the full list of external partners and collaborating institutions see Page 12.

46 total faculty, **46** postdocs and graduate students, and **75** undergraduate students were involved with the CREWS project in Year 4.

Cumulative total amount of grant funding awarded to CREWS researchers by the end of Year 4. Several project researchers leveraged CREWS work and support to secure major new grants in Year 4, including a $20M award received by Dr. Jerry Downey and others at Montana Technological University (learn more about this award on Page 8.).



DIRECTORS UPDATE

The CREWS project showcases how Montana higher education institutions can work together to provide science, technology, and education in support of issues that impact the people of the state. In Year 4 we continued the strong success of projects established in previous years and established new projects; we are now in our last year. The CREWS team is poised to complete the goals and objectives we established almost five years ago and many of these are highly sustainable and should extend impacts for years.

Year 4 was also an important milestone in that we were able to meet in person as a full team for the first time since the pandemic. Students, faculty, staff, and partners came together in Anaconda, Montana in September of 2020 to talk about progress, opportunities, and needs. We plan to hold a Year 5 All Hands team meeting in the fall of 2023 in Missoula. Although the CREWS team is adept at using a variety of technical tools to engage across distances, meeting together in person provides unique opportunities for meaningful discussion and team building.

In Year 4, a new team of researchers from Montana submitted an NSF RII Track-1 project proposal that, if funded, will start a new 5-year $20 million research, outreach, and education effort in areas of prescribed fire and smart sensors. We are confident that Montana will be successful and follow in CREWS footsteps in successful partnership with NSF EPSCoR.

All the best,

Ray Callaway & Todd Kipfer

A map illustrating CREWS partner institutions. CREWS was developed as a partnership between the University of Montana (UM), Montana State University (MSU), Montana Technological University (MTU), Salish Kootenai College (SKC), and Little Big Horn College (LBHC). Through competitive seed funding opportunities, new higher education partners include Carroll College, University of Montana Western (UM-W), Montana State University-Billings (MSU-B), and Rocky Mountain College (RMC).

CREWS HOSTS FIRST IN-PERSON ALL HANDS MEETING SINCE 2019

In Year 4 the CREWS project hosted its annual All Hands meeting. At this meeting, project researchers, students, staff, and partners gathered to share their work, learn about progress across CREWS teams, and engage in targeted discussions, working sessions, and networking opportunities with others on the project. Excitingly, this CREWS All Hands meeting, hosted in Anaconda, MT, was the first in-person project-wide meeting held since 2019. The project looks forward to continued engagement with everyone in Year 5.

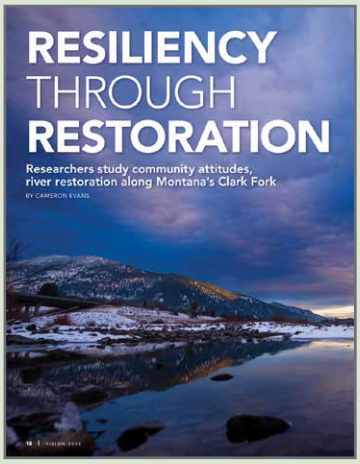
CREWS researchers, students, staff, and partners from across the state gathered at the Forge Hotel in Anaconda, MT from September 7-8 for the project's first in-person All Hands meeting since 2019. The All Hands meeting is an opportunity for project participants to share updates on their work and connect with the broader CREWS community. *Photo credit: Todd Kipfer.*

UPPER CLARK FORK RIVER

Students from Montana State University and the University of Montana work on the Upper Clark Fork River to assess algae levels, both through hyperspectral imaging with a drone and collecting algal samples directly from the river. *Photo credit: Lark Olson.*

CREWS researchers and students working on the Upper Clark Fork River (UCFR) continued to focus on understanding how interactions between nutrients and metals influence river food webs. The team monitors water-borne nutrients and metals, and in Year 4 completed algal assessments showing that concentrations of major metals in the UCFR generally decline with increasing biomass of algae. CREWS researchers deployed autonomous sensors at six sites in the Clark Fork River to measure dissolved oxygen, partial pressure of carbon dioxide, alkalinity, and pH. Sensor deployments ranged from days to months at a time. These data contributed to a robust four-year data set that informed CREWS graduate student dissertations, and stream water metals data products are currently being finalized.

In addition to extensive field work, CREWS faculty also modeled the relationship between gas exchange respiration estimates and established metabolism estimate protocols in the UCFR. CREWS researchers also developed a model for metal ion capture that will contribute to work on the Continuous Flow Metal Recovery (CFMR) system, which began to incorporate natural stream water samples in Year 4. In the lab, other team members characterized selenium adsorption in Fall 2021. UCFR lab work also shifted in Year 4 to focus on maximizing magnetic nanoparticle capture and retention in natural waters. Groups from UM and MTU collaborated on research related to the effects of magnetic nanoparticles in mesocosms, with plans to execute their studies in the coming year. The UCFR team will examine metal adsorption characteristics and evaluate the selectivity of metal ion adsorption from surrogate and real stream samples in Year 5.



CREWS RESEARCHERS FEATURED ON PROJECTS STUDYING IMPACTS OF MINING AND RESTORATION

The 2022 edition of the University of Montana's (UM) Vision magazine featured a story on CREWS research in the Upper Clark Fork River. Vision is published annually by the UM Office of the Vice President for Research and Creative Scholarship and includes stories on UM research, innovation, and imagination. The magazine article, titled "Resiliency through Restoration," features interviews with CREWS researchers Dr. Libby Metcalf and Dr. Maury Valett and focuses on research related to the perceptions and impacts of mining in the region. In addition, CREWS graduate student Taylor Gold Quiros was featured in the magazine's Student Spotlights section, which highlights her efforts to understand how copper mining has impacted fish communities in the Upper Clark Fork River. Find the 2022 Vision magazine at **https://scholarworks.umt.edu/vision/28/**.

JUDITH RIVER WATERSHED

In Year 4, the CREWS Judith River Watershed (JRW) made progress on examining and addressing contamination in the region's streams and groundwater. JRW researchers and students continued to link hydrologic and biogeochemical pathways and expanded the installation of groundwater wells to multiple riparian sites. Wells were outfitted with sensors to measure conductivity and water levels. CREWS researchers and students will integrate data from the wells with a geophysical assessment of shallow groundwater and stratigraphy. Further, the data will be coupled with hyperspectral imaging and a plant community assessment to determine the dynamics of riparian connections to area surface waters. Additional fieldwork in Year 4 involved shorter but more intensive follow-up campaigns to deploy stream sensors at the study sites.

CREWS-JRW team researchers published an article and associated dataset in Year 4 that documents nitrate isotopes in soils, and others are drafting another manuscript that focuses on the input of snow and snow water isotopes to soils, groundwater, and riparian areas. CREWS researchers are developing a soil water model to quantify snow contributions to agricultural production in drought conditions. CREWS faculty are also modeling stream-riparian dynamics and are expanding the model's infrastructure to incorporate the simulation of isotopic composition. Finally, the team made progress in Year 4 on modeling soil water and nitrate transport. Moving forward, they will explore how stream corridor systems remove nitrogen in agricultural landscapes through the study of solute processing signals.

JRW researchers and students working in the laboratory identified iron oxide photoexcitation as a source of an iron(II) aqueous species and investigated the fate and impact of iron(II) species with respect to nitrate and nitrite reduction. They also identified design criteria for engineered photocatalytic materials and evaluated polymer and semiconductor nanoparticle photocatalysts for catalytic behavior. Finally, CREWS faculty and students working in the lab used spectroscopic measurements to identify key features of efficient nitrate reduction in C3N4 hybrid systems. Moving forward, the team will conduct spectroscopic studies of nanoparticles to help refine their design criteria for engineered photocatalytic materials.

CREWS researchers and students collect water samples from a stream in the Judith River Watershed. These samples will provide valuable information to the research team, including improved understanding of how diel patterns in nitrate and oxygen impact microbiome taxonomy in the area's waterways. *Photo credit: Claire Wells.*

CREWS RESEARCH LEAD NAMED AS NEW DIRECTOR OF MONTANA WATER CENTER

Dr. Stephanie Ewing was named the new Director of the Water Center in 2022 after Dr. Wyatt Cross returned to his full-time faculty status after an impressive eight years leading the Center. Dr. Ewing, a Professor in the Department of Land Resources and Environmental Sciences at Montana State University, is a CREWS co-PI and the research lead for the CREWS Judith River Watershed team. Ewing was appointed to a three-year term as Director. With funding from the U.S. Geological Survey through the Water Resources Research Act, Dr. Ewing will lead Montana's Water Center to develop and support water research, outreach, and education across the Montana University System.

Dr. Stephanie Ewing, who is a co-PI on the current Track-1 CREWS project and the research lead for the CREWS Judith River Watershed team, was recently named as the new director of the Montana Water Center. *Photo credit: Montana State University.*

POWDER RIVER BASIN

The CREWS Powder River Basin (PRB) team remained on track with their research goals and objectives in Year 4. In the laboratory, most of the team's work focused on examining fundamental chemical interactions that affect the dissolution of gypsum, a key contaminant in the region's waters. Their studies tested the effect of different alkyl surfactants on gypsum dissolution, and they found that a common organic compound, SDS, helped suppress long-term dissolution of gypsum in water. CREWS graduate and undergraduate students used a combination of spectroscopic tools and conductometric titrations to characterize SDS and other compounds. These findings resulted in presentations at national meetings and one published paper, with another paper in preparation. The PRB team's results also spurred the development of novel hypotheses for mechanisms that disrupt water structure. PRB researchers and students will assess how findings made in the laboratory translate into observations in streams and groundwater in the region.

Another significant PRB team effort in Year 4 was quantifying area groundwater-surface water relationships and how these relationships impact sulfate concentrations. In May 2022, members of the PRB team collected groundwater and surface water samples from field sites, building off sampling work in previous years 2020 and 2021. The team analyzed the 2020 and 2021 samples for metals and salts, and cataloged, curated, and posted these results to the Montana Bureau of Mines and Geology (MBMG) Ground Water Information Center (GWIC) database. Team researchers are also currently conducting isotopic analyses on water samples to assess the impact of mining activity and spoils generation on groundwater sulfate. In this work, a graduate student from MSU is leveraging conceptual developments from the Upper Clark Fork River and Judith River Watershed to evaluate PRB results based on flow-path modeling.

CREWS researcher Liddi Meredith and former CREWS undergraduate researcher Allie Wolverton use their mobile lab during field work in the Powder River Basin. *Photo credit: Stephanie Ewing.*

The PRB team is also making progress on activities delayed by COVID-19; analysis of the chemistries of home well water samples collected on the Crow Reservation. Their results clarified the effects of drought and hotspots that mobilize iron and arsenic in home well water, and were presented at two undergraduate research symposia. PRB researchers also completed a review of Crow Reservation home and well water contaminants, with samples collected from select wells across the reservation currently being analyzed by the MSU Environmental Analytics Laboratory (EAL). Members of the team plan to report their findings back to the Crow Community when the results have been analyzed and interpreted, and the threat of COVID-19 has subsided.

SYSTEMS ECOLOGY AND EARTH SCIENCES

In Year 4, CREWS researchers from the Systems Ecology and Earth Sciences (SEES) team made substantial progress toward developing a theoretical basis for assessing the balance between solute transport and transformation in environmental waters. In Fall 2021, the SEES team met in-person and developed two conceptual papers focused on the theoretical basis for SEES research. CREWS research faculty led an effort to formalize biogeochemical reference frames and explore the utility of a storage exchange reference frame. In this work, the SEES team developed a simulation model of stream corridors and conducted experiments in these simulated stream corridors. This modeling effort was the focus of a manuscript submitted to Water Resource Research and is currently under review. The SEES team also used a second approach in this effort by reviewing rate-limited reactive transport. Ultimately, SEES work and modelling in Year 4 served as a foundation for assessing solute transport and reaction in different contexts. Moving forward, the team will expand their stream-reach based model to incorporate aspects of other processing domains. In the project's final year, SEES researchers anticipate using their simulations to address how contamination from metals and pollutants impacts such process domains.

ENVIRONMENTAL SENSORS, SYNOPTICS, AND SIGNALS

The Environmental Sensors, Synoptics, and Signals (ESSS) team used sensor technology to better understand contaminated waters and their influence on ecosystem function. Notably, several CREWS graduate students made important contributions to the work and goals of the ESSS team. At UM, graduate student Qipei Shangguan conducted an in-depth examination of in-situ CO2 and O2 data from both the UCFR and JRW. In this effort, they deployed CO2, NO3, and O2 sensors in the UCFR, and worked closely with MSU researchers and students to deploy sensors in 64 locations across the JRW. They also evaluated different modeling approaches for estimating the gross primary production of streams. Working closely with CREWS researchers from MSU and Flathead Lake Biological Station, they evaluated the sensitivity of the models to different input parameters. Importantly, they also helped uncover recurring sources of modeling errors, and demonstrated through their research the appropriate uses of single-sensor and two-sensor locations.

Similarly, at MSU, CREWS graduate student Madison Foster made substantial progress on the development of methods used to compare nitrate and oxygen signals in JRW stream corridors. They used both empirical and process-based modeling approaches to evaluate nitrate processing signals observed in JRW streams. This student presented at multiple conferences and is preparing a manuscript that contributes to a holistic framework for inferring whole-stream corridor nutrient processing.

Finally, CREWS engineering graduate student Riley Logan at MSU furthered ESSS work related to drone-based hyperspectral imaging. Logan deployed drones throughout the UCFR and JRW in close consultation with ecology students and faculty, leading to meaningful and significant collaborative relationships. This work led to the preparation of a journal article that describes the methodology and results of drone-based hyperspectral imaging, with co-authorship spanning several CREWS groups and disciplines. Undergraduate students at MSU also helped extensively with this work through fieldwork and analysis and will be co-authors on the paper.

TWO CREWS UNDERGRADUATE STUDENTS AWARDED GOLDWATER SCHOLARSHIPS IN 2022

Two CREWS undergraduate research students, Shannon Hamp and Baylie Phillips, were awarded Goldwater Scholarships in 2022. The Goldwater Scholarship is the most prestigious award in natural sciences, engineering, and mathematics in the United States and is given to sophomores and juniors who show exceptional promise to be the next generation of research leaders in their fields.

Shannon Hamp, a student at Montana State University (MSU) majoring in electrical and computer engineering, became involved with CREWS through a Research Experience for Undergraduates (REU) project in 2021 working in Dr. Joseph Shaw's lab. She assisted with drone-based hyperspectral imaging of algae in the Judith River Watershed and the Upper Clark Fork River, while also developing a low-cost multispectral imager for river algae detection.

Baylie Phillips, a student at Montana Technological University (MTU) majoring in metallurgical and materials engineering, worked with Dr. Jerry Downey in 2021 as a CREWS undergraduate research intern, where she investigated selenium absorption and removal in Continuous Flow Metal Recovery systems. Phillips' research continues to encompass a broad array of disciplines but focuses mainly on exploring the life cycle of materials and removing materials from environmental systems.

CREWS undergraduate students Shannon Hamp, left, and Baylie Phillips, right, both received Goldwater Scholarships in 2022. Hamp is a student at Montana State University and Phillips is a student at Montana Technological University. The Goldwater Scholarship is one of the most prestigious awards given to undergraduate students in the natural sciences, engineering, and mathematics. *Photo credit: Kelly Gorham; Baylie Phillips.*

MOLECULAR ENGINEERING AND ENVIRONMENTAL SCIENCE

The Molecular Engineering and Environmental Science (MEES) group continued to work on understanding the transformation, transport, and persistence of contaminants and nutrients in water systems. CREWS researchers from MSU tested a novel technique for denitrifying polluted water by using silver nanoparticles as a photocatalytic denitrification material. In collaboration with researchers from MTU, results from this work were published in ACS Omega. MTU faculty continued to study how to improve the efficiency of natural water denitrification processes, and results from this work will be published in collaboration with researchers from MSU and Sandia National Laboratories. In addition, MTU researchers used ultrafast spectroscopy to study charge separation mechanisms in a hybrid photocatalyst system. The goal of this ongoing work is to understand the impact of developing light absorbing materials with catalytic metal nanoparticles. Members of the MEES group also characterized a novel nanoparticle-scaffold system using transmission electron microscopy.

A core theme for the MEES group in Year 4 was strengthened relationships and collaboration among colleagues. CREWS faculty from UM worked with the MTU group to better characterize iron nanoparticles found in the Clark Fork River. Using the Continuous Flow Metal Recovery System (CFMR) developed at MTU, the researchers examined how much CFMR could remove contaminants from the river. Building on this work, they plan to conduct a mesocosm experiment that will further examine how CFMR processes impact ecosystem structure. Exciting work on the CFMR system has expanded beyond surrogate water testing and has shifted to focus on using it to test natural stream water samples.

Teagan Leitzke, a CREWS graduate student, works on the Continuous Flow Metal Recovery (CFMR) system in the Downey Lab at Montana Technological University. The goal of Leitzke's work is to develop an economical and environmentally friendly technique for removing contaminants like lead and copper from affected waters. *Photo credit: Montana Technological University.*

Finally, CREWS researchers and students from MSU published and presented work related to understanding the effects of solute partitioning on model biological membranes as well as herbicide and carbon particle interactions with biological membranes. From this work, two papers have already been published, three submitted, and two are currently in preparation for submission.

MONTANA TECH AWARDED $24M TO DEVELOP MATERIALS TECHNOLOGY FOR RARE EARTH ELEMENT PROCESSING RESEARCH PROGRAM

Montana Technological University (MTU) was awarded a five-year $24M research and development grant from the Army Research Laboratory (ARL) to develop a research program called "Materials Technology for Rare Earth Elements Processing." Dr. Jerry Downey, a CREWS research lead at MTU, will be the PI for the award. Dr. Grant Wallace, a Research Associate in Dr. Downey's research group, will act as co-PI. The program, developed in partnership with the Montana Bureau of Mines and Geology (MBMG), will build on the advances of the Continuous Flow Metal Recovery system developed during the current Track-1 CREWS project and will include analysis of large waste systems of the Butte-Anaconda mining complex and Montana coal mines. The goal of the program is to develop innovative, environmentally friendly, and industrially viable methods for recovering and separating rare earth elements, and ultimately lay the groundwork for economically and environmentally-sound utilization of rare earth elements in the United States.

NATURAL RESOURCE SOCIAL SCIENCE

The Natural Resource Social Science (NRSS) team made significant strides in Year 4 of the project. One of their most notable accomplishments was the execution and completion of a survey-questionnaire across JRW and UCFR communities, which required extensive collaboration across campuses and research sites. The NRSS team evaluated metrics, developed questions, tested their measures, and are currently analyzing data. NRSS faculty, postdoctoral researchers, and graduate students worked with the Montana Bureau of Business and Economic Research (BBER) on sampling and survey methods. They developed a novel sampling design because the JRW and UCFR are unique with respect to scope and size, including communities ranging from small villages to large towns. Ultimately, the team used census block sampling to develop a list of survey recipients. In 2022, they collected over 900 completed surveys. In the coming year the team will focus on analyzing, interpreting, and disseminating the survey results.

In addition to the survey, the NRSS team participated in a community event hosted by spectrUM in the town of Anaconda. For the event, NRSS postdoctoral researcher Amanda Bailey worked with the CREWS outreach team at spectrUM to develop an educational program for community residents. NRSS graduate student Megan Moore also asked residents at the event to think about past and present memories related to a mining smokestack landmark in the area. This activity integrated ideas from Moore's dissertation research around collective memory and ties to resilience. At SKC, the NRSS team developed a survey to administer to Flathead Valley River Corridor residents focused on perceptions of rivers and waters. This data will help SKC researchers understand how rivers are incorporated into broader outreach efforts.

WORKFORCE DEVELOPMENT AND COMMERCIALIZATION

CREWS developed and supported three internship programs in Year 4. These included the Undergraduate Research internship, Innovation and Commercialization internship, and Workforce Development internship. Four students from UM and MSU participated in the Undergraduate Research internship in Summer 2022. Students in the Innovation and Commercialization internship conducted market research and explored the commercial viability of their ideas under the guidance of a faculty mentor and industry partner. Three students from UM and MSU participated in the Innovation and Commercialization internship program. Finally, the Workforce Development internship supported five students from UM and MTU over Summer 2022. In this internship, students were placed with a partnering company or agency to work on a specific project.

CREWS continued to provide professional development and STEM education training in partnership with the Science Math Resource Center (SMRC) at MSU. In Fall 2021, the SMRC completed an Educator Needs Assessment which gathered insights into professional development needs of Montana K-12 educators. SMRC and CREWS also delivered four teacher workforce development opportunities that included CREWS content. One opportunity was the Supercharge Your Classroom with Field Science Data course, which taught educators on how to utilize authentic datasets and content from EPSCoR researchers. This course was developed in partnership with OPI and hosted through the Montana Teacher Learning Hub and taught by two award-winning K-12 Montana teachers. Finally, SMRC hosted a virtual Diving into Data workshop which featured CREWS datasets and attracted Montana teachers from across the state, primarily from rural schools. As part of this workshop, two CREWS graduate students gave lightning talks to teachers about CREWS research.

Student Intern	Host Organization	INTERNSHIP PROJECT
Gabriella Cameron (UM)	Sunburst Sensors	Hand-Held pH Meter Testing and Application Development
Morgan Schultz (MTU)	Clark Fork Coalition	Fish Habitat Data
Emily Towery (UM)	Trout Unlimited	Flint and Rock Creek Restoration and Monitoring
Sam Turner (UM)	U.S. Geological Survey	Studying Emerging Aquatic Invertebrates in the UCFR with USGS
Raina Woolworth (UM)	RESPEC	Scientific Consulting: Environmental Monitoring & Assessment

The CREWS Workforce Development internship program supported five undergraduate students from across the Montana University System during Summer 2022 (Year 4 of the project). These students worked directly with government agencies, NGOs, and other private businesses in Montana who are partners of the CREWS project. Through the internship, students gained hands-on experience in different sectors and further explored their academic, professional, and personal interests and goals.

OUTREACH

As part of its Year 4 activities, CREWS project staff, faculty, and students continued to develop and deliver hands-on learning activities based on CREWS research. Several student camps and workshops at MSU featured CREWS-focused education and outreach activities, including the MSU Explore: Earth and Space Science Camp, MSU Family Science Day, and a Water Day held at Bozeman's Chief Joseph Middle School. Personnel from the Science Math Resource Center (SMRC) at MSU are also developing a virtual camp under the Sensing for Science umbrella that includes a complimentary program for pre-service teachers.

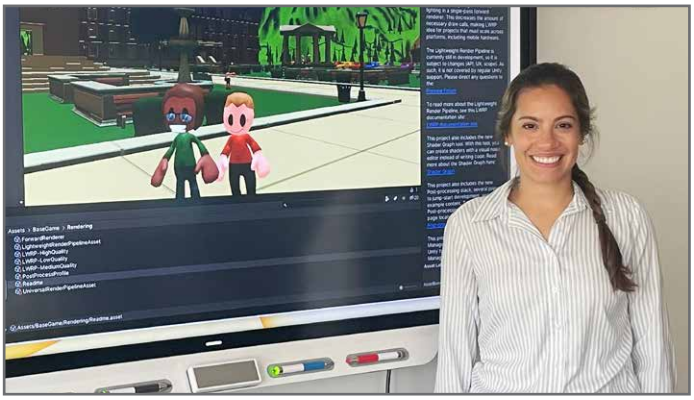
At the UM spectrUM Discovery Area, over 31,000 individuals, the majority of them K-12 students, engaged with the Water Exhibition at both the Missoula-based museum and through mobile science opportunities across the state. The spectrUM Science on Wheels programming delivered hands-on science activities to schools in Anaconda, the Bitterroot Valley, and the Flathead Indian Reservation. spectrUM also piloted a Sensing for Science Road Show at a school in Anaconda with a CREWS UM graduate student; this event engaged over 250 students on the Upper Clark Fork River. Finally, spectrUM served an additional 6,000 students over Summer 2022 through hands-on activities, summer camps, and mobile programming in the Bitterroot Valley and Flathead Indian Reservation.

CREWS graduate student Megan Moore poses with the spectrUM Sensing for Science Roadshow booth in Anaconda. For the event, Moore and others from spectrUM and CREWS developed educational materials for community members and facilitated an activity that integrated ideas from Moore's dissertation research around collective memory and ties to resilience. *Photo credit: Jessie Herbert-Meny.*

MONTANA NSF EPSCOR SUPPORTS GAME-BASED LEARNING TO HELP YOUNG PEOPLE EXPLORE STEM PATHWAYS

One of the highlights of Montana NSF EPSCoR's Year 4 Outreach efforts has been supporting the development of an online video game based on the Success Prints Crash Course® board game. This online game will allow high school students to engage in a virtual college experience and introduce them to various STEM concepts and pathways. As part of Montana NSF EPSCoR's support for the game, staff from the Science Math Resource Center (SMRC) worked with MSU and UM faculty, graduate students, and undergraduate students to build the game and incorporate stories from CREWS researchers and students into it. The web browser-based video game will debut in Spring 2023.

During the story-crafting process, two major goals emerged. The first was to educate players about the variety of research and career opportunities available to STEM students. Special attention was given to sources of inspiration – passionate professors, teachers, parents, relatives, and counselors – mentioned by CREWS participants. A second focal point was the need to dispel common misconceptions and stereotypes about what it means to be a scientist, particularly for women or people who have been under-represented in STEM. In their stories, several CREWS students expressed common fears, stigmas, and hurdles that they encountered during their educational journeys, such as the idea that all scientists are naturally gifted in math and chemistry, that scientists aren't creatively inclined, that being a successful scientist and mother is nearly impossible, and that the work itself is always solitary and lonely.



Tasha Striker, a graduate student in the Department of Education at Montana State University, poses with a developer version of the virtual College Simulator game. With support from Montana NSF EPSCoR, the game will allow high school students to engage in a virtual college experience and introduce them to various STEM concepts and pathways. *Photo credit: Suzi Taylor.*

All in all, the college success video game story is an amalgamation of the authentic experiences of CREWS team members and other STEM students and professionals. The game will uniquely showcase these experiences in a way that inspires, demystifies, and destigmatizes scientific research and encourages a future generation to consider a career in STEM.

DIVERSITY

In Year 4 of the project, CREWS continued to provide Indigenous STEM education opportunities for K-12, undergraduate, and graduate students in Montana. CREWS supported five Montana State University undergraduate students to attend summer training through the IWIKUA Exchange. This Exchange was part of the Honor Bound Program, an American Indian and Alaska Native student recruitment and retention initiative in MSU's Honor College. Over the Summer of 2022, CREWS supported five indigenous graduate students at the University of Montana. Over 100 middle and high school students from the Flathead, Blackfeet, Crow, Navajo, and Northern Cheyenne reservations participated in the Montana American Indians in Math Science (MT AIMS) program, which is housed in the Indigenous Research and STEM Education program at UM, over Summer 2022. In addition, math and science tutors from the American Indian Student Services at UM continued to assist undergraduate students in their studies and classwork.

The Montana Girls STEM Collaborative, an outreach program of Montana NSF EPSCoR that serves all youth typically underrepresented in STEM, had several notable accomplishments in Year 4. The Collaborative was accepted into three national programs that leveraged EPSCoR funding to bring forty-thousand dollars in STEM resources to Montana in Fall 2021. One such program was the national IF/THEN Coalition, which showcases women role models in STEM. Through funding from the IF/THEN Coalition, the Collaborative was able to support mini-grants for eight Montana youth organizations. The Montana Girls STEM Collaborative was also selected by competitive application to receive an "Anniversary Fellow" by the National Girls Collaborative Project. The Montana fellow is a program specialist with the University Corporation for Atmospheric Research (UCAR) Science Education who creates citizen science-related programming for girl-serving organizations in Montana.

At MSU, the Empower program co-sponsored a talk for Little Big Horn College and Blackfeet Community College students and faculty and hosted a campus visit for Blackfeet Community College students. Empower also worked with STEM faculty at Chief Dull Knife College and Little Big Horn College to plan a STEM faculty professional development session. Finally, the CREWS team at spectrUM collaborated with professionals at Salish Kootenai College, Stone Child College, and Blackfeet Community College to develop content for K-12 education that includes native science activities.

THOMAS LEADS $10M PROJECT TO ADVANCE NATIVE AMERICAN STEM EDUCATION ACROSS WEST

Members of the six-state CIRCLES Alliance pose for a picture. The goal of the CIRCLES Alliance is to inform educational institutions and the NSF in Native cultural understanding and humility and to shift approaches toward AI/AN education. *Photo credit: University of Montana News.*

The National Science Foundation (NSF) awarded $10M in 2022 to a six-state collaborative working to boost the underrepresentation of Alaska Native and American Indian (AI/AN) students in STEM disciplines and the workforce. The grant award funds Cultivating Indigenous Research Communities for Leadership in Education, or the CIRCLES Alliance. The CIRCLES Alliance launched in 2020 with support from NSF's EPSCoR and INCLUDES programs (INCLUDES: Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science). The Alliance is led by principal investigator Dr. Aaron Thomas, who is a Diversity and Inclusion lead on the current Track-1 CREWS project, a University of Montana (UM) chemistry professor, and Director of UM Indigenous Research and STEM Education. The CIRCLES Alliance partners include universities and research institutions in Idaho, Montana, New Mexico, North Dakota, South Dakota, and Wyoming. UM will receive $1.8M of the total award to build a network for developing and disseminating science, technology, engineering, and math educational resources, as well as implementing longitudinal programming, mentorship, and teacher preparation in support of AI/AN student success. Ultimately, through research and collaboration with tribal communities, the CIRCLES Alliance aims to inform educational institutions and the NSF in Native cultural understanding and humility and to shift approaches toward AI/AN education.

CREWS PARTNERS AND COLLABORATORS

BROADER ENGAGEMENT

American Computer and Robotics Museum
Bitterroot College
Bitterroot Public Library
Blackstone LaunchPad
Boys and Girls Club of Flathead Reservation and Lake County
Boys and Girls Club of Missoula County
City of Missoula Parks and Recreation
Clark Fork Watershed Education Program
Corvallis School District
Families First Learning Lab
Hamilton School District
Lewistown Boys & Girls Club
Lewistown Public Library
Montana Afterschool Alliance
Missoula Butterfly House and Insectarium
Missoula Community Access Television
Missoula Food Bank & Community Center
Montana Outdoor Science School
Missoula Public Library
Missoula Water
MSU Academic Technology and Outreach
MSU Empower
MSU Science Math Resource Center
North Lake County Public Library
Ravalli County Museum and Historical Society
Rosebud Conservation District
School Services of Montana
SciNation on the Flathead Reservation
spectrUM Discovery Area
UM Broader Impacts Group
UM Indigenous Research and STEM Education

RESEARCH

Clark Fork Coalition
Crow Environmental Health Steering Committee
GCS
Geum Environmental Consulting
Internet2
Jackson State University
Montana Bureau of Mines and Geology
Montana Department of Agriculture
Montana Department of Environmental Quality
Montana Fish Wildlife and Parks
Montana Natural Resources Conservation Service
Montana Natural Resource Damage Program
Montana Rural Water Systems
Missoula Department of Public Works
Montana Climate Office
Montana Institute on Ecosystems
Montana Water Center
MSU Central Agricultural Research Center
MSU Environmental Analytical Laboratory
MSU Extension
Resonon
RESPEC Consulting
Rithron Associates, Inc.
Sandia National Laboratories
Semper Cogito Consulting
Sunburst Sensors
Trout Unlimited
UM Bird Ecology Lab
UM Environmental Biogeochemistry Laboratory
UM Flathead Lake Biological Station
University of Alaska Fairbanks
University of Hawaii
University of Minnesota
University of New Mexico
University of Nevada Reno
US Fish and Wildlife Service
University of Vienna
US Geological Survey
Water & Environmental Technologies
Western Washington University
York College

LAND ACCESS

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