INFORMATIONAL
FEBRUARY 16, 2023

SUBJECT

Semi-Annual Report of Approved Program Requests

REFERENCE

August 2020	Board received the semi-annual report
February 2021	Board received the semi-annual report
August 2021	Board received the semi-annual report
February 2022	Board received the semi-annual report
August 2022	Board received the semi-annual report

APPLICABLE STATUTE, RULE, OR POLICY

Idaho State Board of Education Governing Policies and Procedures, Section III.G., Postsecondary Program Review and Approval.

BACKGROUND/DISCUSSION

In accordance with Board Policy III.G.3.a.ii and 4.b., prior to implementation, the Executive Director or designee may approve actions related to academic and career technical programs or units as identified in those subsections.

Consistent with Board Policy III.G.9.a., the Board office is providing a semi-annual report of academic and career technical program requests from Idaho's public postsecondary institutions that were approved by the Executive Director or his designee between July 1, 2022, and December 31, 2022. A report of program change requests approved by the full Board for the same time period, as well as a longitudinal view of program approvals and discontinuations over the past several years, are also included for informational and contextual purposes.

ATTACHMENTS

Attachment 1 – Semi-Annual Report of Approved Program Requests
Attachment 2 – Longitudinal View of Program Approvals and Discontinuations

BOARD STAFF COMMENTS AND RECOMMENDATIONS

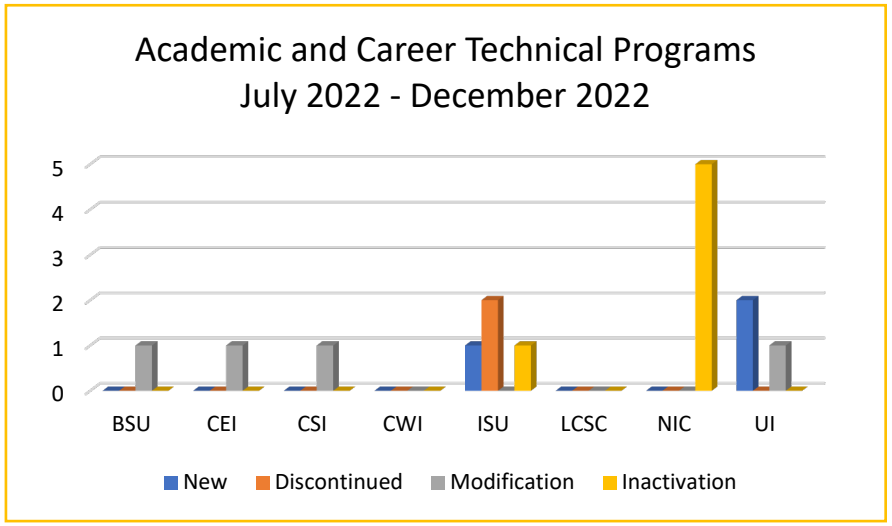
The report provides a list of new academic or career technical programs and certificates approved by the Executive Director or his designee consistent with Board Policy III.G. This includes other instructional activity such as modifications to existing programs. Other non-substantial changes that require notification to the Board office are also included in the report.

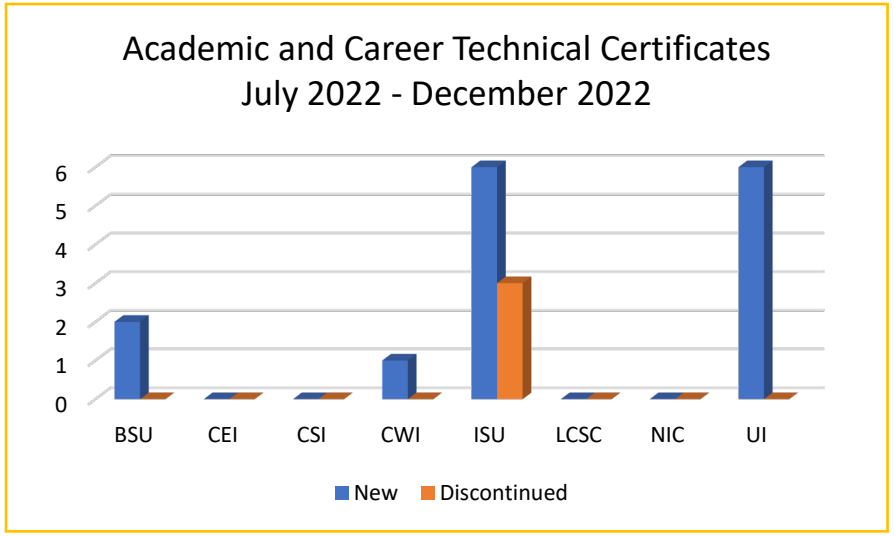
For this current reporting cycle, there were fewer program requests submitted for review and approval. Staff notes there were more certificates established versus degree programs and fewer discontinuations. There was an increase in program inactivation. This action does not discontinue a program but rather provides institutions with opportunities to reevaluate and assess industry need and demand and where appropriate make program improvements for marketability. Staff will update charts in Attachment 1 and provide a comprehensive annual trend analysis in August 2023.

BOARD ACTION

This item is for informational purposes.

Semi-Annual Report of Approved Program Requests
July 2022 through December 2022





List of Academic Program and Unit Requests Approved by Executive Director or Designee

INST.	Request Type	Program Title	Type	Date
UI	New	English	BS	12/27/2022
UI	New	Nutritional Sciences	MS	12/27/2022
ISU	Discontinuance	Department of Informatics	N/A	8/19/2022
ISU	Discontinuance	Business Informatics (online and face-to-face)	BBA	8/19/2022
ISU	Discontinuance	Business Admin. (Informatics Emph.)	MBA Emph.	8/19/2022
BSU	New Instructional Unit	School of Computing	N/A	11/7/2022
BSU	New Instructional Unit	Department of Humanities and Cultural Studies	N/A	11/26/2022
BSU	New Administrative Unit	Center for Research and Creative Activity	N/A	8/31/2022
BSU	New Administrative Unit	Idaho Election Cybersecurity Center (INSURE)	N/A	9/14/2022
ISU	New Administrative Unit	Office of Health and Wellness and U. of Utah Psychiatry Residency	N/A	8/31/2022
ISU	New instructional unit	Department of Physics	N/A	7/29/2022
ISU	New instructional unit	Department of Clinical Psychopharmacology	N/A	8/19/2022
CSI	Modification	Split Health Sciences & Human Services Department to establish Nursing Department and Health Professions Department	N/A	8/31/2022
ISU	Modification	Split Department of Physical and Occupational Therapy into Dept. of Occupational Therapy and Dept. of Physical Therapy & Athletic Training	N/A	9/26/2022

List of Other Academic Program/Unit Changes Notified to Executive Director

The following program changes or additions do not require approval; however, they require notification to OSBE per policy III.G.

INST.	Request Type	Program Title	Certificate Type	Date
ISU	New	Human Resources (online)	Academic Certificate	11/7/2022
UI	New	Robotics Engineering	Graduate Certificate	11/8/2022
BSU	New	Applied Computing, Systems, and Network (online)	Undergraduate Certificate	11/15/2022
BSU	Expansion	Computed Tomography (online)	Undergraduate Certificate	11/16/2022
BSU	Expansion	Diagnostic Medical Sonography (online)	Undergraduate Certificate	11/16/2022
BSU	Expansion	Magnetic Resonance Imaging (online)	Undergraduate Certificate	11/16/2022
BSU	New	Culture and History Through Film	Undergraduate Certificate	11/17/2022

INST.	Request Type	Program Title	Certificate Type	Date
UI	New	Modern Language Study	Graduate Certificate	11/28/2022
UI	New	Technical Writing	Undergraduate Certificate	11/28/2022
UI	New	Social Media Management	Undergraduate Certificate	11/28/2022
ISU	New	Information Systems	Academic Certificate	12/7/2022
ISU	Discontinuance	Business Administration	Post-Bacc Certificate	12/7/2022
ISU	Discontinuance	Nuclear Science and Engineering / Applied Nuclear Energy	Post-Bacc Certificate	12/7/2022
ISU	New	Nursing Education	Graduate Certificate	12/8/2022
ISU	New	Pharmacy Technology	Academic Certificate	12/16/2022
ISU	New	Lifestyle Medicine	Graduate Certificate	12/16/2022
UI	New	Environmental Hydrogeology	Undergraduate Certificate	12/22/2022
UI	New	Climate Change	Graduate Certificate	12/22/2022

Other Program Changes

INST.	Request Type	Program Title	Program Type	Date
ISU	New	Sport Management: Coaching emphasis	BA | Emphasis	11/21/2022
ISU	New	Sport Management: Sport Operations emphasis	BA | Emphasis	11/21/2022
UI	Discontinuance	American Studies	Minor	11/29/2022
BSU	New	New emphases under the BS in Anthropology Program • Archaeology emphasis • Cultural Anthropology emphasis • Evolutionary Medicine and One Health emphasis • Evolution, Ecology, and Behavior emphasis • Forensic Science emphasis	Emphases	12/5/2022
BSU	New	New emphases under the Bachelor of Applied Science • Early Childhood Education emphasis • Project Management emphasis	Emphases	12/5///2022
UI	New	Cybersecurity	Minor	11/28/2022
UI	New	Agricultural Commodity Risk Management	Minor	11/28/2022
UI	Modification	Change name of undergraduate Crop Science program to Crop Science and Managements (does not impact statewide program responsibilities list)	B.S.Pl.Sc.	11/28/2022

INST.	Request Type	Program Title	Program Type	Date
BSU	Modification	Change name of Resort Operations and Hospitality Management emphasis under the BBA in Management to Resort and Hospitality Management emphasis	BBA Emphasis	11/10/2022
BSU	Discontinuance	General History with Geographic Focus	Minor	11/17/2022

List of Career Technical Program Requests Approved by State Administrator (by Type)

INST.	Request Type	Program Title	Degree	Date
ISU	New	Industrial Maintenance Mechanic	BTC | ITC	12/22/2022
ISU	Expansion	Industrial Cybersecurity Engineering Technology Apprenticeship (online)	AAS	12/22/2022
CWI	Expansion	Medical Assistant	BTC	12/13/2022
NIC	Inactivation	Pharmacy Technology	ITC	9/15/2022
NIC	Inactivation	Carpentry	ITC	9/15/2022
NIC	Inactivation	Medical Assistant	ITC | AAS	9/15/2022
NIC	Inactivation	Construction Management	AAS	9/15/2022
ISU	Inactivation	Computerized Machining Technology: CNC Programmer	BTC	12/27/2022
ISU	Discontinuance	Advanced Automation and Manufacturing Technology	AAS | ITC	12/22/2022

List of Other CTE Program Changes Notified to State Administrator

The following program changes or additions do not require approval; however, they require notification to OSBE per policy III.G.

INST.	Request Type	Program Title	Degree	Date
NIC	CIP Code Change	Physical Therapy Assistant	AAS	9/6/2022
CEI	Name Change	Radiation Safety to Health Physics Technologies	ITC	12/2022

List of Academic Program Requests Approved by the Board

INST.	Request Type	Program Title	Degree	Date
UI	Modification	Environmental Design	B.S.	9/14/2022

SUBJECT

Higher Education Research Council Annual Report for Fiscal Year 2022

REFERENCE

February 2017	The Board was provided the annual update of the Higher Education Research Council for FY16 and approved the second reading of amendments to Board Policy III.W.
February 2018	The Board was provided the annual update of the Higher Education Research Council for FY17
June 2019	The Board was provided the annual update of the Higher Education Research Council for FY18
June 2020	The Board was provided the annual report of the Higher Education Research Council for FY19
June 2021	The Board was provided the annual report of the Higher Education Research Council for FY20
February 2022	The Board was provided the annual report of the Higher Education Research Council for FY21

APPLICABLE STATUTE, RULE, OR POLICY

Idaho State Board of Education Governing Policies and Procedures, Section III.W. Higher Education Research

BACKGROUND/DISCUSSION

Board Policy III.W. Higher Education Research recognizes the significant role research plays in innovation, economic development, and enhanced quality of educational programs. By developing and leveraging the state's unique research expertise and strengths, Idaho's universities and colleges serve as catalysts to spur the creation of new knowledge, technologies, products, and industries. This in turn leads to new advances and opportunities for economic growth.

The Board's Higher Education Research Council (HERC) provides recommendations to the Board regarding statewide collaborative efforts and initiatives to accomplish these goals and objectives. In addition, HERC provides direction for, and oversees the use of, the limited resources allocated by the Board for higher education research by promoting research activities that will have the greatest beneficial effect on the quality of education and the economy of the state.

HERC also administers the Incubation Fund and HERC Idaho Global Entrepreneurial Mission (IGEM) Fund programs, disbursement of Infrastructure Funds, and the oversight of matching funds for our Idaho Established Program to Stimulate Competitive Research (EPSCoR) Track 1 project (Managing Idaho's Landscapes for Ecosystem Services) on the Board's behalf and in compliance with Board Policy III.W. Additional responsibilities include receiving annual reporting on the institutions' activities in relation to the Center for Advanced Energy Studies (CAES).

Incubation Fund projects are single-year projects that are at the proof-of-concept stage. Through a competitive process, HERC awards funds to those projects where the principal investigator can rapidly move their project into the development stage. IGEM Fund projects are awarded for competitive state university research in support of the goals of the Idaho Global Entrepreneurial Mission (IGEM) initiative. These funds are to be used as seed funding for strengthening Idaho's future by strategically investing in the development of expertise, products, and services which result in state economic growth. While these awards may be for up to three years, the funding is contingent upon successful progress as determined by HERC at an annual review of the project.

CAES is a research and education consortium among the three Idaho public research institutions (Boise State University, Idaho State University, University of Idaho), and the Idaho National Laboratory. The most recent annual CAES report was provided with the FY20 HERC Annual Report provided to the Board in June 2021. Thus, no CAES report is included in this item.

IMPACT

Taking a strategic approach to invest in the state's unique research expertise and strengths will lead to new advances and opportunities for economic growth and enhance Idaho's reputation as a national and international leader in excellence and innovation. This update will provide the Board with the opportunity to provide ongoing input to the Higher Education Research Council on areas of focus and strategic direction, especially as it engages in the process of developing the next five-year higher education research strategic plan.

ATTACHMENTS

Attachment 1 – FY22 HERC Report Presentation
Attachment 2 – FY22 HERC Budget Allocation
Attachment 3 – FY22 Research Performance Measure Report
Attachment 4 – FY22 Research Activity Reports
Attachment 5 – FY22 Infrastructure Summary Reports
Attachment 6 – FY22 Undergraduate Research Report
Attachment 7 – FY22 Idaho Conference on Undergraduate Research Report
Attachment 8 – FY22 IGEM Grant Reports

BOARD STAFF COMMENTS AND RECOMMENDATIONS

This report will be provided by the Chair of HERC, Dr. Nancy Glenn, Vice President for Research and Economic Development at the Boise State University.

BOARD ACTION

This item is for informational purposes only.

Higher Education Research Council

Report on activities from July 1, 2021 - June 30, 2022
(Fiscal Year 2022)

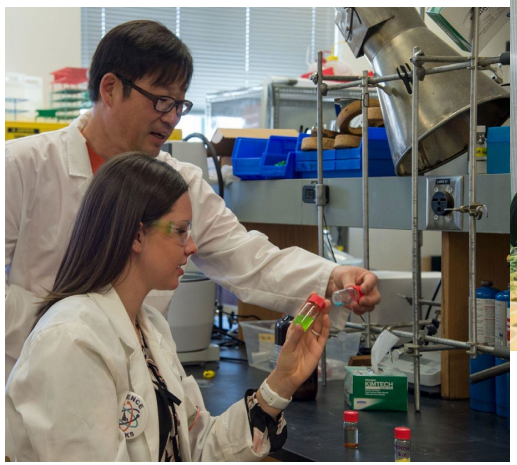
Dr. Nancy Glenn, Chair

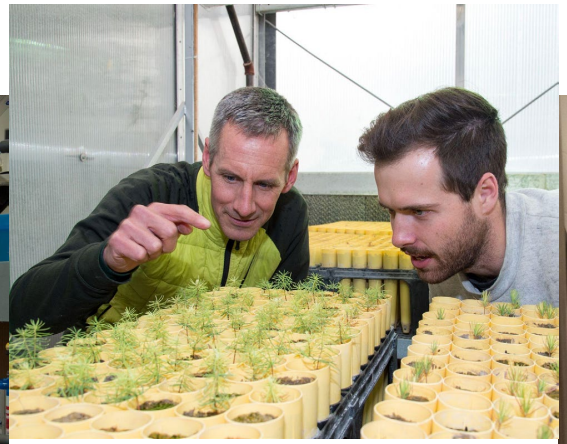
Attachments

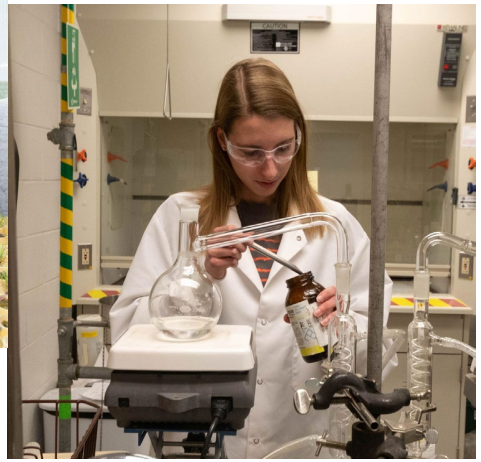
- FY22 HERC Budget Allocation
- FY22 HERC Research Performance Measure Report
- FY22 Research Activity Reports
- FY22 Infrastructure Summary Reports
- FY22 Undergraduate Research Reports
- FY22 Idaho Conference on Undergraduate Research Report
- FY22 Incubation Fund Grant Report
- FY22 IGEM Grant Reports

HERC Mission

Strengthen the research capabilities at Idaho's public, four-year institutions and contribute to the economic development of the state of Idaho.







Purpose, Vision, and Role of HERC

- **Purpose:** To provide vision, leadership and strategic financial support to the research endeavors at Idaho's higher education institutions.

- **Vision:** Idaho will become a research destination in key discipline areas.

- **Role:** To manage HERC funds, influence the research endeavor in higher education in Idaho, and monitor key factors that might impact the funder and influencer roles HERC plays.

HERC Membership

Higher Education Representatives

Dr. Nancy Glenn, *Boise State University (Chair)*

Dr. Martin Blair, *Idaho State University*

Dr. Christopher Nomura, *University of Idaho*

Dr. Grace Anderson, *Lewis-Clark State College*

Industry Representatives

Marianne Walck, *Idaho National Laboratory*

Eileen Barber, *Keynetics*

Heather Messenger, *Life Sciences and Biotech Industry*

Douglas Sayer, *Premier Technology Inc.*

HERC Impact

HERC has invested just under $12.5M in 8 major projects since 2016.
These projects have resulted in…

$52.5M
External funding received

450+
Students involved in research projects

345
Jobs created in Idaho

205+
Peer-reviewed scientific articles published

12
Patents awarded or pending

4
Companies launched in Idaho

FY22 HERC Budget Allocation

Research Infrastructure Funds	$854,000
Matching Grants (EPSCoR)	$800,000
Undergraduate Research	$265,000
Incubation Fund	$100,000
IGEM Grants	$2,017,000
Administrative Costs	$38,800
Total	**$4,074,800**

Research Infrastructure

Funding to support science, engineering, and other research infrastructure

FY22 Infrastructure Budget - $854,000

Major line items:

BSU – Research Equipment purchased: HPC (High Performance Computing) Equipment & Software, and Mainali Physics Lab. In addition, some monies used as start-up funds for new hires

ISU – Research Equipment purchased: Change out Station for Animal Facilities, computers bought for the GIS Center, key instrument to run samples of organic carbon, nitrogen and inorganic carbon, new Millipore system, YSI meters and probes, automated groundwater chemistry sampler, audiology equipment, and a Project Suite software license

UI – Research Equipment purchased: Research Computer and Data Services equipment upgrades; EPSCoR management payroll expenses; funding for faculty to acquire additional research data to strengthen competitive proposal resubmissions

LCSC – Library expenses: EBSCO-Nature, England Online Journal 2021, Infobase Learning – Master Academic College. In addition, salary and fringe for LCSC State Librarian to support undergraduate and faculty research efforts.

Undergraduate Research

Funding to support STEM undergraduates in research projects and travel to conferences

FY22 UR Budget: $265,000:

BSU – 17 at $3,000 each

ISU – 17 (6 projects that included 2-3 students each). An additional 13 students were awarded travel funds to attend research conferences across the country. 3 students presented posters at the National Conference on Undergraduate Research

UI – 13 SURF awards at $4,000-$5,000 each. Plus, 5 additional students at $1,000 each to help with their research for materials and supplies and other project-related expenses.

LCSC – 12 students supported in their semester long or year long projects

Idaho Conference on Undergraduate Research (ICUR)

Funding for two-day undergraduate conference held each July. During FY22 it was held on July 20 & 21.

FY22 ICUR Budget - $30,000

FY22 ICUR Highlights/Outcomes:

- 481 people registered for the event
- 344 attendees participated in zoom sessions from over 30 different institutions/organizations
- 553 project collaborators including 249 undergraduate students, 84 graduate students and 161 faculty (plus some postdoctoral fellows, high school students, and other community members students)
- 194 poster presentations

Idaho Conference on Undergraduate Research (ICUR)

Quotes from attendees:

1. *"Attending ICUR enabled me to directly connect with students and faculty via discussions and LinkedIn. ICUR reinforced the fact that undergraduates are doing incredible things in Idaho and are solving problems!"* - Student, Idaho State University
2. *"My biggest take-away is that I know what I am doing and I am chosen for the project for a reason. I should not let things like "Imposter Syndrome" get in the way because it only hinders what I am able to achieve."* - Student, University of Idaho
3. *"I feel more confident as a researcher in my field. I know that there are many other people across many fields that are experiencing the same or similar struggles and victories."*- Student, Boise State University
4. *"Listening to these students talk about their incredible research gives me such hope for the future. The students inspire me.*" - Educator, Boise State University
5. *"Great opportunity for undergraduate students to gain experience, exposure to other institutions, and grants to help in research."* - Educator, Lewis-Clark State College
6. I think that linking the universities is the most beneficial experience for the students and I think they see that too. In many ways our students are in bubbles and they need to see what research looks like at other places and in other disciplines especially as undergrads. - Educator, University of Idaho

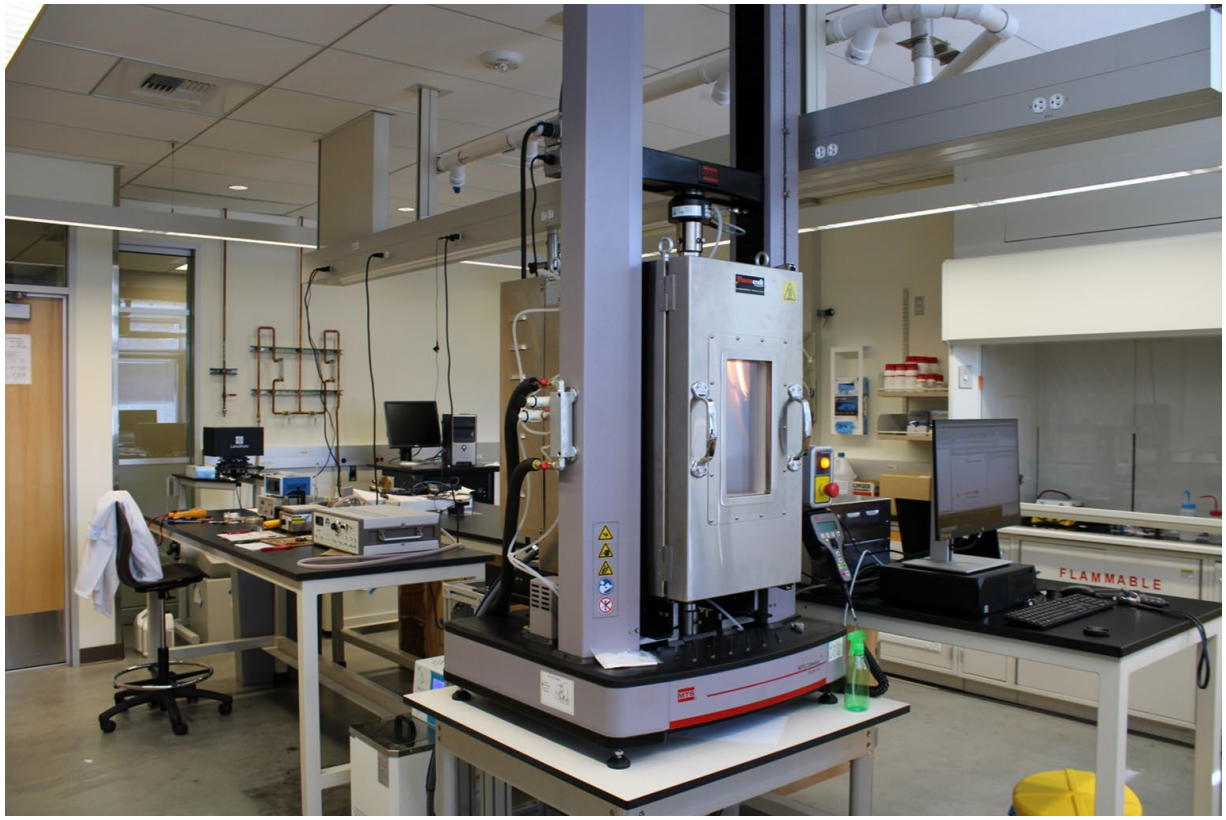
Incubation Fund

Funding for faculty members at the state's baccalaureate/post-baccalaureate institutions for research that demonstrate potential for economic benefit or cost savings for the State.

1-year grants

FY22 IF Grant Budget: $100,000

Active Grant in FY22: 1



IF22-001: Multiphysics Characterization of Printed Smart Materials and Systems, $100,000 for 1 year

BOISE STATE UNIVERSITY

Impact:

1. Established new thermomechanical and acoustic testing infrastructure. These new multiphysics characterization capabilities have strengthened collaborations with NASA centers and Idaho National Laboratory.
2. Provided students hands-on learning experience, and trained MS and undergraduate students on state-of-the-art dynamic materials test technology.

Idaho Global Entrepreneurial Mission Fund (IGEM)

Competitive grant program used as seed funding for strengthening Idaho's future by strategically investing in the development of expertise, products, and services which result in state economic growth.

1- to 3-year grants up to $700,000 per year

FY22 IGEM Grant Budget – $2,017,000

Active Grants in FY22: 4

FY22 Active IGEM Grants

IGEM 20-001: A Disaster Response Complex for Emergency Responders in Idaho

Idaho State University – $283,100 – Year 3

IGEM 20-002: Cellulosic 3D Printing of Modular Building Assemblies

University of Idaho – $349,900 – Year 3

IGEM 22-001: The Cyberdome: An Investment in Idaho's Cybersecurity Future

Boise State University - $700,000 – Year 1

IGEM 22-002: Boise State University Food and Dairy Innovation Center

Boise State University - $684,000 – Year 1

IGEM 20-001: A Disaster Response Complex for Emergency Responders in Idaho - Yr 3

Impact:

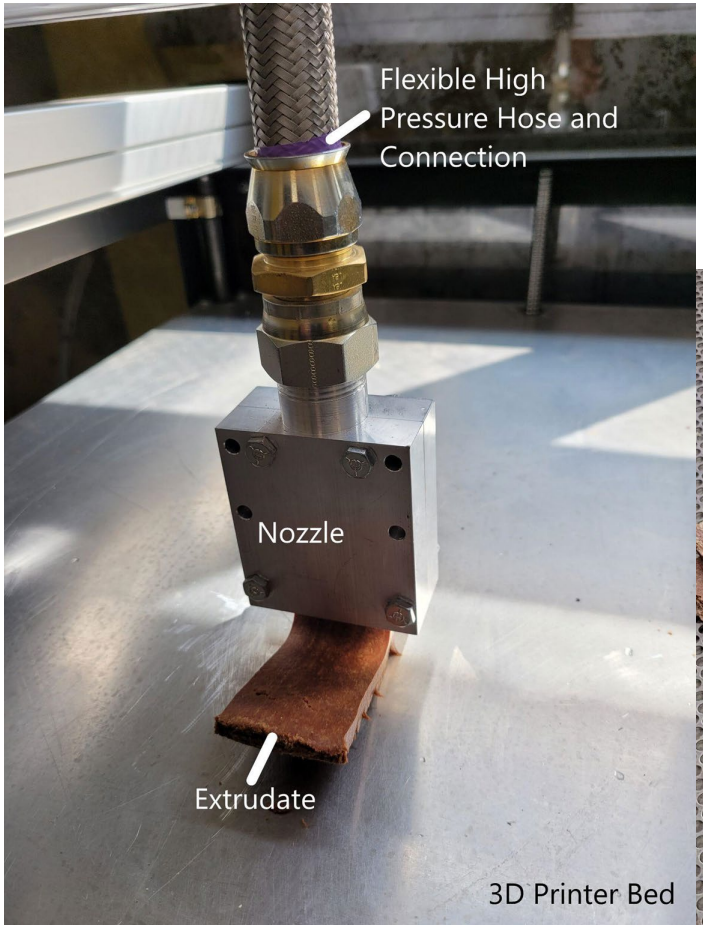
1. 1,500 emergency responders trained.

1. Trained 200+ military participants, including Civil Support Teams from 20 states.

1. Research collaborations in mobile robotics and human factors engineering.

Idaho State University

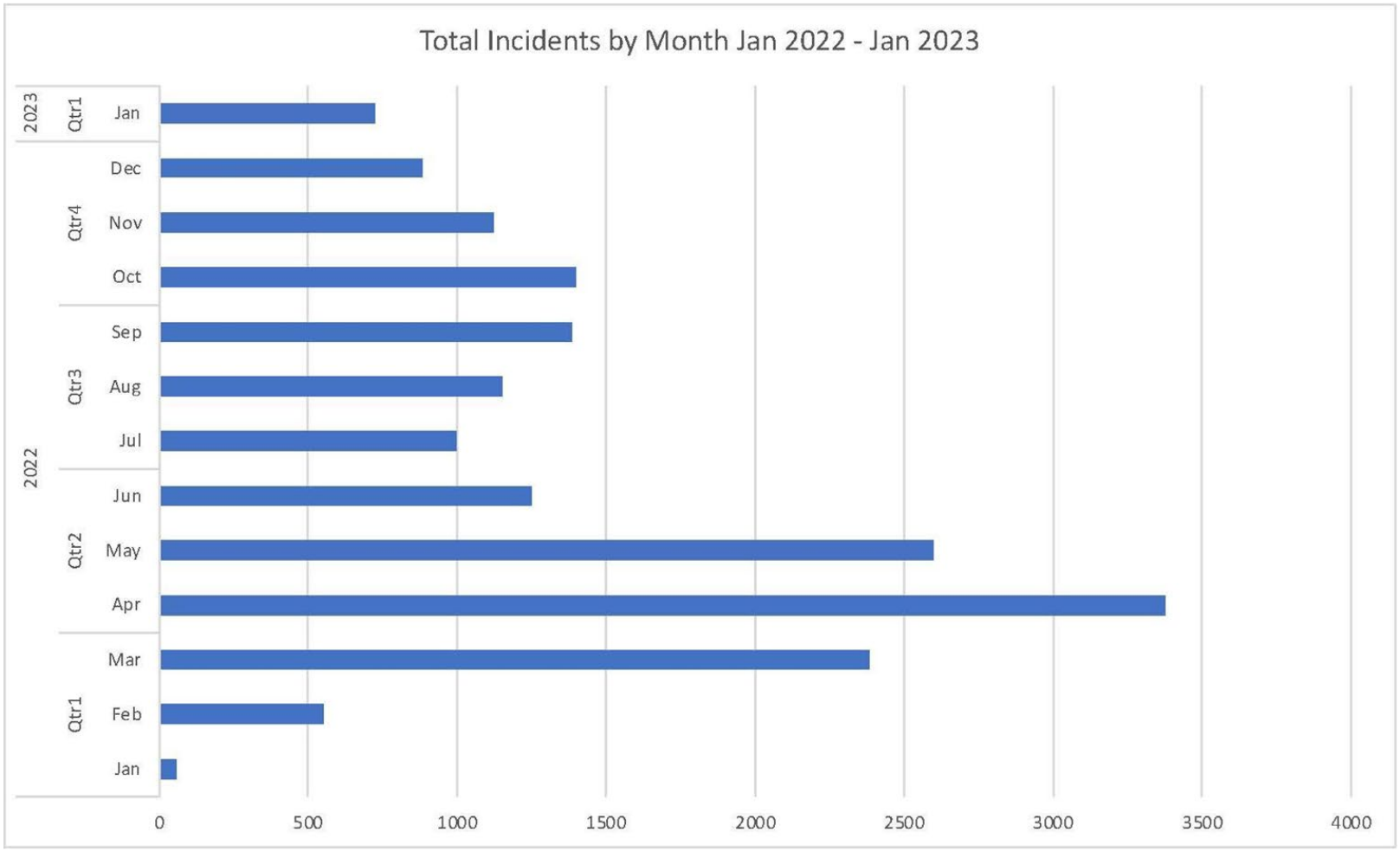
IGEM 20-002: Cellulosic 3D Printing of Modular Building Assemblies - Yr 3



University of Idaho
A LEGACY OF LEADING

IGEM 22-001: The Cyberdome: An Investment in Idaho's Cybersecurity Future - Yr 1

BOISE STATE UNIVERSITY



Reflects 122,337 identified client alerts. These alerts yielded 17,000 incidents after analysis

IGEM 22-002: Boise State University Food and Dairy Innovation Center - Yr 1

FDIC: People, partners, impact for Idaho businesses

Thank You

Idaho State Board of Education

IF22-001: Multiphysics Characterization of Printed Smart Materials and Systems

- Task 1: Acquire and install the MTS test system. The proposed MTS load frame system was delivered on May 25, 2022. Load frame installation, on-site calibration, and user training were eventually completed on July 11-13, 2022. In addition, the new MTI fotonic probe system was delivered on May 14, 2022.
- Task 2: Provide instrument training and increase visibility. Students from the PI's lab were trained by MTS technicians on July 13, 2022. Training sessions were recorded and standard testing templates (e.g., tensile or cyclic testing) were prepared for future users.
- Task 3: Characterize thermomechanical loops of printed shape memory polymers. Using a Geeetech A30M fused filament printer, the PI's lab has fabricated shape memory polymer (SMP) dogbone samples by mix printing polylactic acid (PLA) and thermoplastic polyurethane (TPU) filaments. The PI's lab has also customized SMP filaments by extruding PLA and TPU pellets in a 50:50 volume fraction. On a Hyrel Engine SR printer, the PI printed the first-ever morphing electrical circuit by innovatively merging direct ink writing and fused filament deposition. The PI's lab has completed the tensile testing of printed SMP dogbone samples at room temperature.
- Task 4: Characterize the Young's modulus of magnetostrictive iron-gallium alloys. Since the domestic Galfenol provider (TdVib llc.) went out of business in Oct 2021, the PI selected magnetostrictive terbium-iron-dysprosium (Terfenol-D) for this task instead. The PI has printed the first-ever magnetostrictive composites using direct ink writing.
- Task 5: Seek for long-term funding sources to support sustainable research and product commercialization. This project received additional funding and has some pending proposals in the works as well.

IGEM 20-001: A Disaster Response Complex for Emergency Responders in Idaho (ISU)

- The Disaster Response Complex (DRC) at Idaho State University continues to offer various opportunities for training/exercise, curriculum and certification, and research projects to various groups and entities.
- Since the start of 2022 the DRC has hosted varies events for the Forest Service, Bannock County, training collaborators, law enforcement, health professionals and Idaho's 101st Civil Support Team.
- The DRC also offered the first annual Disaster Preparedness & Response Conference, April 8th and 9th. More than 75 individuals attended the conference and shared encouraging feedback and support for the conference to be offered continually in the years to come.
- **Current Status:** The DRC and Bannock County are collaborating to design a Regional Emergency Operations Center (REOC) to serve the southeast region of Idaho. The DRC is currently planning to host various OSHA, Rad Tech, Medical, Confined space, and operations course throughout the remainder of the year. The DRC continues to grow its facilities, abilities, and network to better serve the needs of the community.

IGEM 20-002: Cellulosic 3D Printing of Modular Building Assemblies (UI)

- Identify a methodology, process, and materials necessary to 3-D cold print building assemblies using wood fibers.
- Primary objective is the development of a cost-effective and reliable process for printing wall, roof, and floor assemblies on a horizontal plane.
- Target market is light commercial, residential and multi-family buildings.
- **Current Status:** The project was successful in developing a wood-resin formulation that was extrudable and suitable for additive manufacturing (AM). In addition, a 3D printer platform was constructed (2'x 3' x 2') and wood-resin panels were successfully printed, and their performance evaluated. This project provided a springboard for attaining further funding ($4million from NSF) to develop a fully biobased AM platform. The team has also been in discussion with the Department of Defense and USDA-Forest Products Laboratory to attain funding ($300k) for precommercial development of the technology and a demonstration project.

IGEM 22-001: The Cyberdome: An Investment in Idaho's Cybersecurity Future (BSU)

- The Cyberdome is a Security as a Service (SECaaS) oriented platform meant to leverage force-multiplying efforts of our students to secure critical cyber/physical assets of rural and remote clients
- Following receipt of funding in July 2021, the IPC focused on objective #1 from their proposal and successfully hired its two full-time staff members in August and September, respectively.
- Three (3) graduate assistants were enabled in the August and September timeframe.
- Undergraduate student hiring has been ongoing.
- **Current Status:** In the months/fiscal year ahead efforts will focus more heavily on the other two objectives for the project which are to reduce critical cybersecurity risks for State, Local, Tribal, and Territorial (SLTT) clients (objective #2), and produce innovative research, tools, and techniques to transfer to commercial efforts (objective #3).

IGEM 22-002: Boise State University Food and Dairy Innovation Center (BSU)

- The vision of this project is to create a Food and Dairy Innovation Center (FDIC) at Boise State University. The FDIC will utilize science and technology to move beyond the current standards in the food and dairy sectors.
- The center will serve as a research core facility for regional academic institutions and industry.
- This project seeks to catalyze the modernization of Idaho's food and dairy processing industries by creating innovative technologies, providing food safety and food security training, and educating the next generation of workers to be prepared to lead in a high-tech, artificial intelligence (AI) dominated work environment
- In FY22 funds were been spent on personnel, infrastructure, capital equipment, and operating expenses/travel/recharge center fees. The objectives of the FDIC are to create critical infrastructure and generate sponsorship for sustainable industry prioritized research.
- **Current Status:** In FY23, they will begin construction of FDIC laboratories, purchase additional equipment to bolster research capabilities, secure extramural funding with academic and industry partners to expand operations, and recruit and retain student and full-time employees to staff the FDIC

FY 2022 Allocation of HERC Funds

	Allocation	**$4,074,800**
	HERC IGEM	$2,017,000
	Infrastructure Funds	$854,000
	Matching Grants (EPSCoR Match)	$800,000
	Incubation Fund	$100,000
	Undergraduate Research	$265,000
	Administrative Costs	$38,800
TOTAL	**Sum**	**$4,074,800**
BALANCE		

IGEM Funds

ISU	IGEM 20-01	$283,100
BSU	IGEM 22-01	$700,000
UI	IGEM 20-02	$349,900
BSU	IGEM 22-02	$684,000
Total IGEM	***Committed IGEM Funds***	**$2,017,000**

Research Infrastructure Funds

BSU	$250,000
ISU	$250,000
UI	$250,000
LCSC	$104,000
Total Infrastructure	**$854,000**

Matching Award Grants

NSF-EPSCoR	$800,000

Total Matching Grants		**$800,000**
Targeted Research		
Idaho Incubation Fund (8th round)		
BSU	IF 22-001	$100,000
Total Targeted Research		**$100,000**
Undergraduate Research		
BSU		$65,000
ISU		$65,000
UI		$65,000
LCSC		$30,000
Idaho Conference for Undergraduate Research (ICUR)		$40,000
One-time money		
Total Undergraduate Research		**$265,000**
Administrative Costs		
FY21 Administrative Costs		$38,800
Total Administrative Costs		**$38,800**
Total Budget / Allocation		**$4,074,800**

HIGHER EDUCATION RESEARCH - PERFORMANCE MEASURES

Goal 1: Increased research at, and collaboration among, Idaho universities and colleges to advance research strengths and opportunities pertaining to critical issues in Idaho, while also providing a vision for national and global impact.

Objective 1.A: Ensure growth and sustainability of public university research efforts.

Performance Measure	FY 2016	FY 2017	FY2018	FY2019	FY2020	FY2021	FY2022	Benchmark
Statewide amount of total annual research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey	$154,989,123	$163,093,485	$171,052,983	$166,564,099	$170,635,458	$165,912,523	NA	10% annual increase

Objective 1.B: Ensure the growth and sustainability of the existing collaborative research at the Center for Advanced Energy Studies (CAES).

Statewide amount of U.S. Department of Energy (DOE) research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey.	$8,561,218	$9,489,612	$11,022,015	$11,724,216	$13,187,742	$13,559,863	NA	10% annual increase

Objective 1.C: Expand joint research ventures among the state universities.

Number of new fully sponsored project proposals submitted by an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction).	92	119	100	82	94	82	50	50% annual increase
Number of new fully sponsored project awards to an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction).	58	70	76	69	50	34	26	30% annual increase
Establish/fund at least one HERC-directed research project per year which collaborates with one other Idaho university that directly addresses issues of particular importance to the State of Idaho.	NA	NA	NA	UI*/BSU/ISU - Dr. Karen Humes - Integrated Water, Energy and Waste Management				1 per year

Goal 2: Create research and development opportunities that strengthen the relationship between state universities and the private sector.

Objective 2.A: Increase the number of sponsored projects involving the private sector.

Performance Measure	FY 2016	FY 2017	FY2018	FY2019	FY2020	FY2021	FY2022	Benchmark
Number of new sponsored projects involving the private sector.	165	163	172	202	206	193	98	50% annual increase

Goal 3: Contribute to the economic development of the State of Idaho.

Objective 3.A: Increase the amount of university-generated intellectual property introduced into the marketplace.

Performance Measure	FY 2016	FY 2017	FY2018	FY2019	FY2020	FY2021	FY2022	Benchmark
Number of technology transfer agreements (as defined by AUTM [Association of University Technology Managers]).	44	33	29	29	28	37	37	15% annual increase
Number of invention disclosures (including biomic varieties)	40	38	45	46	58	49	17	1 for every $2M of research expenditures
Amount of licensing revenues.	$724,316	$1,271,819	$ 1,869,718	$ 2,607,055	$ 3,450,773	$ 2,626,859	$ 14,506	10% annual increase
Number of startup companies.	8	1	1	1	0	0	1	10% annual increase

Goal 4: Enhance learning and professional development through research and scholarly activity.

Objective 4.A: Increase the number of university and college students and staff involved in sponsored project activities.

Performance Measure	FY 2016	FY 2017	FY2018	FY2019	FY2020	FY2021	FY2022	Benchmark
Number of undergraduate students paid from sponsored projects.	1,683	1,811	2,100	1,926	1,993	2,050	1,651	20% annual increase
Number of graduate students paid from sponsored projects.	636	716	656	592	536	530	176	20% annual increase
Percentage of baccalaureate students who graduated in STEM disciplines and had a research experience.	UI: 60.4%, BSU: N/A, ISU: 13%	UI: 66.0%, BSU: N/A, ISU: 12.1%	UI: 62.7%, BSU: N/A, ISU: 19.6%	UI: 64.4% BSU: N/A ISU: 12.7%	UI: 58.1% BSU: N/A ISU: 19.1%	UI: 57.6% BSU: N/A ISU: 19.0%	UI: 0.0% BSU: N/A ISU: 14.1%	20% annual increase
Number of faculty and staff paid from sponsored projects.	2,272	2,383	2,418	2,446	2,484	2,563	1,455	20% annual increase

K-20 Statewide Stratgic Plan Performance Measures	FY 2016	FY 2017	FY2018	FY2019	FY2020	FY2021	FY2022	Benchmark
Percentage of students participating in undergraduate research.	48%	51%	UI: 61%, BSU: 37% ISU: 45%	UI: 58.4% BSU: 43.0% ISU: 37.7%	UI: 59.6% BSU: 43.0% ISU: 36.2%	UI: 55.5% BSU: 34.0% ISU: 37.0%	UI: 52.7% BSU: 36.3% ISU: Note:	30%
Number of student internships	2,294	2,177	2,156	2,127	2,174	2,020	2,038	

Idaho State University

Performance Measure	FY 2016	FY 2017	FY 2018	FY2019	FY2020	FY2021	FY2022
Statewide amount of total annual research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey	$20,447,000	$18,564,000	$18,081,000	$14,972,000	$14,478,000	$13,953,000	
Statewide amount of U.S. Department of Energy (DOE) research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey.	$3,122,000	$3,290,000	$3,383,000	$2,255,000	$3,310,000	$2,810,000	
Number of new fully sponsored project proposals submitted by an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction).	30	29	27	30	43	38	23
Number of new fully sponsored project awards to an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction).	27	32	35	41	18	17	20
Number of new sponsored projects involving the private sector.	65	65	78	86	96	82	69
Number of technology transfer agreements (as defined by AUTM [Association of University Technology Managers]).	2	0	0	0	0	0	0
Number of invention disclosures (including plant varieties)	6	3	7	0	2	3	4
Amount of licensing revenues.	$100,000	$0	$0	$0	$0	$0	$50
Number of startup companies.	3	1	0	0	0	0	
Number of undergraduate students paid from sponsored projects.	150	169	199	158	150	176	217
Number of graduate students supported by sponsored projects	173	172	156	125	118	140	176
Number of baccalaureate students who graduated in STEM disciplines and had a research experience.				325	211	228	145
Percentage of baccalaureate students who graduated in STEM disciplines and had a research experience.	13.00%	12.10%	19.56%	12.70%	19.11%	19.00%	14.06%
Number of faculty and staff paid from sponsored projects.	257	247	192	170	163	187	221
K-20 Statewide Stratgic Plan Performance Measures							
Percentage of students participating in undergraduate research.	43%	42%	41%	38%	36%	37%	37%
Total amount of research expenditures	$27,670,658	$20,447,000	$11,990,499	$9,679,295	$10,373,549	$8,718,443	$10,761,064
Institution expenditures from competitive Federally funded grants	$22,215,191	$19,557,131	$17,798,317	$15,344,558	$13,185,550	$26,853,236	$15,566,020
Institution expenditures from competitive industry funded grants	$1,411,000	$1,940,336	$1,911,606	$1,846,551	$2,450,614	$1,815,117	$2,069,761
Measure of production of intellectual property:							
Number of startups	3	1	0	0	0	0	0
Number of patents	11	0	1	1	1	2	1
Number of Student internships	896	904	898	877	831	926	835
Percentage of students participating in internships	7.1%	7.6%	7.9%	8.0%	7.7%	8.8%	7.9%

University of Idaho

Performance Measure	FY2016	FY2017	FY2018	FY2019	FY2020	FY2021	FY2022
Statewide amount of total annual research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey (See Note B below)	$102,457,123	$109,537,485	$111,589,983	$111,766,099	$112,850,458	$105,894,523	
Statewide amount of U.S. Department of Energy (DOE) research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey.	$3,694,218	$4,128,612	$3,926,015	$5,065,216	$5,309,742	$5,408,863	
Number of new fully sponsored project proposals submitted by an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction).	18	30	23	17	16	18	
Number of new fully sponsored project awards to an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction).	12	12	14	9	11	6	
Number of new sponsored projects involving the private sector (see Note A below).	65	65	66	82	77	76	
Number of technology transfer agreements (as defined by AUTM [Association of University Technology Managers]).	13	5	5	4	6	15	
Number of invention disclosures (including plant varieties)	18	21	24	26	35	30	
Amount of licensing revenues.	$570,469	$1,232,588	$1,844,878	$2,549,919	$3,434,777	$2,621,175	
Number of startup companies.	0	0	0	0	0	0	
Number of undergraduate students paid from sponsored projects.	697	696	765	660	657	660	
Number of graduate students supported by sponsored projects	463	544	500	467	418	390	
Number of baccalaureate students who graduated in STEM disciplines and had a research experience (Note B)	366/606	403/611	360/574	386/599	387/666	339/589	
Percentage of baccalaureate students who graduated in STEM disciplines and had a research experience. (***Note B***)	60.40%	65.95%	62.71%	64.44%	58.11%	57.56%	
Number of faculty and staff paid from sponsored projects.	1,231	1,269	1263	1293	1268	1276	
K-20 Statewide Strategic Plan Performance Measures							
Percentage of students participating in undergraduate research. (***Note B***)	58.80%	64.58%	61.07%	58.36%	59.57%	55.53%	52.68%
Total amount of research expenditures	$55,893,584	$57,114,745	$57,082,023	$57,612,801	$57,934,326	$55,878,740	
Institution expenditures from competitive Federally funded grants	$63,328,954	$64,092,411	$65,309,507	$65,138,101	$69,162,654	$68,022,683	
Institution expenditures from competitive industry funded grants (see Note A below).	$5,300,451	$4,801,296	$5,225,755	$5,580,184	$6,610,854	$5,579,950	
private sector	$1,825,722	$1,804,800	$1,758,830	$1,742,295	$2,662,227	$2,004,386	
private sector federal flow through	$3,474,729	$2,996,496	$3,466,925	$3,837,889	$3,948,627	$3,575,564	
Measure of production of intellectual property:							
Number of startups	0	0	0	0	0	0	
Number of patents	3	1	1	0	4	1	
Number of student internships	909	879	812	789	854	691	709
Percent of student internships	6.64% (909 of 13700)	6.42% (879 of 13700)	5.65%	5.62%	6.17%	5.54%	5.68%
Number of students participating in undergraduate research (Note B)	992	1,001	812	789	854	691	709

Performance Measure Explanatory Notes:

Note A - Activity with private sector/industry - (a) is funding from private sector, and (b) is funding from private sector, federal flow through.

Note B - Due to process improvement, previous years have been corrected to reflect correct figures.

	2016	2017					
Institution expenditures from competitive industry funded grants (Note A)	$1,825,722 (a); $3,474,729 (b)	$1,804,800 (a); $2,996,496 (b)					

	2016	2017					
Number of new sponsored projects involving the private sector (See Note A above)	47 (a); 18 (b)	47 (a); 19 (b)					

Boise State University

Performance Measure	FY 2016	FY 2017	FY 2018	FY2019	FY2020	FY2021	FY2022
Statewide amount of total annual research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey	$32,085,000	$34,992,000	$41,382,000	$39,826,000	$ 43,307,000.00	$ 46,065,000.00	
Statewide amount of U.S. Department of Energy (DOE) research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey.	$1,745,000	$2,071,000	$3,713,000	$4,404,000	$ 4,568,000.00	$ 5,341,000.00	
Number of new fully sponsored project proposals submitted by an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction). [1]	44	60	50	35	35	26	27
Number of new fully sponsored project awards to an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction).[2]	19	26	27	19	21	11	6
Number of new sponsored projects involving the private sector. [3]	35	33	28	34	33	35	29
Number of technology transfer agreements (as defined by AUTM [Association of University Technology Managers]).	29	28	24	25	22	22	37
Number of invention disclosures (including plant varieties)	16	14	14	20	21	16	13
Amount of licensing revenues.*	$53,847	$39,231	$24,840	$57,136	$15,996	$5,684	$14,456
Number of startup companies.	5	0	1	1	0	0	1
Number of undergraduate students paid from sponsored projects.	836	946	1136	1108	1186	1214	1434
Number of graduate students supported by sponsored projects. **							
Number of baccalaureate students who graduated in STEM disciplines and had a research experience (Note B)							
Percentage of baccalaureate students who graduated in STEM disciplines and had a research experience.**							
Number of faculty and staff paid from sponsored projects.	784	867	963	983	1053	1100	1234
K-20 Statewide Stratgic Plan Performance Measures							
Percentage of students participating in undergraduate research.	35.20%	37.40%	37.00%	43.00%	43.00%	34.00%	36.30%
Total amount of research expenditures	$18,865,799	$21,094,099	$27,718,837	$27,011,840	$29,828,258	$34,718,954	$35,272,900
Institution expenditures from competitive Federally funded grants	$19,306,479	$21,172,738	$26,311,205	$26,190,711	$28,502,836	$35,423,892	$42,021,306
Institution expenditures from competitive industry funded grants	$2,020,959	$2,939,578	$3,836,908	$3,620,844	$3,577,275	a. $666,167.25 b. $2,866,041.31	a. $652,559.69 b. $1,983,532.61
private sector	$562,457	$681,147	$674,882	$259,884	$441,074	$666,167	652,559.69
private sector federal flow through	$1,458,501	$2,258,432	$3,162,027	$3,360,960	$3,136,201	$2,866,041	$1,983,533
Measure of production of intellectual property:							
Number of startups	5	0	1	1	0	0	1
Number of patents	4	3	3	2	5	1	8
Number of disclosures	16	14	14	20	21	16	13
Number of Student internships [4]	489	394	446	461	489	403	494
Number of students participating in undergraduate research	490	567	494	459	459	352	400

[1] Represents the number of full proposal submissions that involved a financial relationship with another Idaho institution of higher education.
[2] Represents the number of new awards that involved a financial relationship with another Idaho institution of higher education.
[3] Represents the number of new awards that involved a financial relationship with the private sector.
[4] Internship information is based on estimates by academic year (e.g., FY09=Academic year Summer 2008 through Spring 2009).
* 2013, 2014 - Licensing revenue includes $30k/year for Micron Licensing Restriction Agreement and is not considered net for OTT.
**Undergraduate and Graduate student totals have been combined into one line as BSU does not have the ability to break this information out.
**Undergraduate and Graduate student totals have been combined into one line as BSU does not have the ability to break this information out.
***FY20 data reflects the prior year. Boise State did not administer the Graduating Student Survey in FY20 because of disruptions due to COVID-19.
****Number includes non-profit DOE national laboratory contractors.

	2016	2017
Institution expenditures from competitive industry funded grants	a. $562,457.27 b. $1,458,502.01	a. $681,146.82 b. $2,258,431.54

	2016	2016
Number of new sponsored projects involving the private sector. [3]	a) 22; b) 13	a) 17; b) 16

Definitions - Approved FY16		
Performance Measure	**How collected/reported**	**Benchmark**
Statewide amount of total annual research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey		10% annual increase
Statewide amount of U.S. Department of Energy (DOE) research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey.		10% annual increase
Number of new fully sponsored project proposals submitted by an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction).	Collaborative new full proposal submissions that include subawards to or awards from other Higher Education institution in Idaho (excludes private higher education institutions).	50% annual increase
Number of new fully sponsored project awards to an Idaho University that involve a subaward with another Idaho institution of higher education (in either direction).	Collaborative new awards that include subawards to or awards from other Higher Education institutions in Idaho (excludes private higher education institutions).	30% annual increase
Number of new sponsored projects involving the private sector.	New awards with Private Sector – to include those that will be awarded from or has subawards to private sector entities, which includes all for profit companies whether domestic or foreign. Number will be broken out as follows: (a) is funding from private sector, and (b) is federal flow through funding passing through a private sector entity.	50% annual increase
by AUTM [Association of University Technology Managers]).		15% annual increase
varieties)	Self explanatory	1 for every $2M of research expenditures
Amount of licensing revenues.	Self explanatory	10% annual increase
Number of startup companies.	Self explanitory	10% annual increase
Number of undergraduate and graduate students paid from sponsored projects.	Represents the number of students (undergraduate & graduate) paid salary, or receiving tuition from sponsored projects.	20% annual increase
Percentage of baccalaureate students who graduated in STEM disciplines and had a research experience.	Raw numbers and percentages	20% annual increase
Number of faculty and staff paid from sponsored projects.	Represents the number of faculty and staff paid salary from sponsored projects.	20% annual increase
K-20 Statewide Stratgic Plan Performance Measures		
Percentage of students participating in undergraduate research.	Raw numbers and percentages	30%
Total amount of research expenditures		
Institution expenditures from competitive Federally funded grants		$112M annually
Institution expenditures from competitive industry funded grants	New awards with Private Sector – to include those that will be awarded from or has subawards to private sector entities, which includes all for profit companies whether domestic or foreign. Number will be broken out as follows: (a) is funding from private sector, and (b) is federal flow through funding passing through a private sector entity. (same as above)	$7.2M annually
Measure of production of intellectual property:		
Number of startups	Same as above	10% annual increase
Number of patents	Same as above	10% annual increase
Number of disclosures	Same as above	10% annual increase
Number of internships	Internship information is based on estimates by academic year (e.g., FY09=Academic year Summer 2008 through Spring 2009) and includes all student internships with private industry where the student received university academic credit.	

Boise State University

Sponsored Project Activity Report FY2022

Awards for the Period July 1, 2021 through June 30, 2022

Activity Type	Federal	State	Industry	Other	Total	% of Grand Total
Instruction:						
Sponsored Programs	$ 2,155,407	$ 1,405,173	$ -	$ 150,654	$ 3,711,234	
State Instruction Appropriations	$ -	$ 100,000	$ -	$ -	$ 100,000	
Subtotal Instruction	$ 2,155,407	$ 1,505,173	$ -	$ 150,654	$ 3,811,234	5.60%
Research:						
Sponsored Programs	$ 32,325,107	$ 1,288,728	$ 858,520	$ 1,035,673	$ 35,508,028	
State Research Appropriations	$ -	$ 1,384,000	$ -	$ -	$ 1,384,000	
Subtotal Research	$ 32,325,107	$ 2,672,728	$ 858,520	$ 1,035,673	$ 36,892,028	54.25%
Other Sponsored Activities:						
Sponsored Programs	$ 22,220,482	$ 3,132,282	$ 213,976	$ 1,304,353	$ 26,871,093	
State Other Sponsored Activities Appropriations	$ -	$ 270,050	$ -	$ -	$ 270,050	
Subtotal Other Sponsored Activities	$ 22,220,482	$ 3,402,332	$ 213,976	$ 1,304,353	$ 27,141,143	39.91%
More Than One Type:						
Sponsored Programs	$ 162,089	$ -	$ -	$ -	$ 162,089	
State More Than One Type Appropriations	$ -	$ -	$ -	$ -	$ -	
Subtotal More Than One Type	$ 162,089	$ -	$ -	$ -	$ 162,089	0.24%
Grand Totals	**$ 56,863,086**	**$ 7,580,233**	**$ 1,072,496**	**$ 2,490,680**	**$ 68,006,494**	
Percent of Grand Total	***83.61%***	***11.15%***	***1.58%***	***3.66%***	***100%***	***100%***

Expenditures for the Period July 1, 2021 through June 30, 2022

Activity Type	Federal	State	Industry	Other	Totals	% of Grand Total
Instruction:						
Sponsored Programs	$ 2,328,672	$ 748,798	$ -	$ 74,515	$ 3,151,985	
State Instruction Appropriations	$ -	$ -	$ -	$ -	$ -	
Subtotal Instruction	$ 2,328,672	$ 748,798	$ -	$ 74,515	$ 3,151,985	5.02%
Research:						
Sponsored Programs	$ 32,178,976	$ 1,420,233	$ 537,452	$ 1,136,239	$ 35,272,900	
State Research Appropriations	$ -	$ 1,282,717	$ -	$ -	$ 1,282,717	
Subtotal Research	$ 32,178,976	$ 2,702,950	$ 537,452	$ 1,136,239	$ 36,555,617	58.27%
Other Sponsored Activities:						
Sponsored Programs	$ 18,994,774	$ 2,213,840	$ 115,108	$ 1,574,056	$ 22,897,778	
State Other Sponsored Activities Appropriations	$ -	$ 127,538	$ -	$ -	$ 127,538	
Subtotal Other Sponsored Activities	$ 18,994,774	$ 2,341,378	$ 115,108	$ 1,574,056	$ 23,025,316	36.70%
Grand Totals	**$ 53,502,422**	**$ 5,793,126**	**$ 652,560**	**$ 2,784,811**	**$ 62,732,918**	
Percent of Grand Total	***85.29%***	***9.23%***	***1.04%***	***4.44%***	***100%***	***100%***

Idaho State University Research Activity Report

Office for Research

Award Breakdown by Funding Agency Type and Project Type

July 1, 2021 through June 30, 2022

	Federal	State	Industry	Other/Foundation	Totals	Percent of Total
Research	6,591,976	4,102,650	2,713,820	959,680	14,368,126	48%
Training and Instruction	5,222,994	1,084,388	1,251,319	386,216	7,944,917	26%
Other/Public Service	1,955,717	4,761,528	572,199	446,116	7,735,560	26%
Totals	13,770,687	9,948,566	4,537,338	1,792,012	30,048,603	100%
Percent of Total	46%	33%	15%	6%	100%	

State = Awards from state of Idaho agencies, including other state universities and colleges

Other/Foundation = Awards from other funding agecnies, such as foundations, universities from outside of Idaho, local municipalities, non-profits, etc.

File Name: ISU OR Annual Awards FY22

Idaho State University Research Activity Report

Office for Research

Expenditure Breakdown by Funding Agency Type and Project Type

July 1, 2021 through June 30, 2022

	Federal	State	Industry	Other/Foundation	Totals	Percent of Total
Research	3,685,639	2,931,735	3,124,991	1,018,700	10,761,065	39%
Training and Instruction	4,947,677	1,630,994	1,475,958	565,128	8,619,757	31%
Other/Public Service	4,057,424	1,942,550	344,094	1,802,494	8,146,562	30%
Totals	12,690,740	6,505,279	4,945,043	3,386,322	27,527,384	100%
Percent of Total	46%	24%	18%	12%	100%	

File Name: ISU OR Annual Expenditures FY22

University of Idaho - FY2021 Research Activity Report

Awards for the Period July 1, 2020 through June 30, 2021

	Federal	State of Idaho	Industry	Other	Total	% of Grand Total	% of Sponsor Total
Instruction:							
Sponsored Programs	$ 2,604,996.00	$ 153,335.08	$ 45,277.50	$ 12,000.00	$ 2,815,608.58		**2%**
	$ 2,604,996.00	$ 153,335.08	$ 45,277.50	$ 12,000.00	$ 2,815,608.58	**2%**	
Research:							
Sponsored Programs	$ 67,811,347.35	$ 2,466,780.04	$ 1,542,741.61	$ 3,450,087.88	$ 75,270,956.88		**61%**
Federal Land Grant Appropriations (FFY21)	2,878,250.00				2,878,250.00		
State Research Appropriations (CALS,FUR,IGS,EPSCoR)		22,439,384.00			22,439,384.00		
Subtotal Research:	$ 70,689,597.35	$ 24,906,164.04	$ 1,542,741.61	$ 3,450,087.88	$ 100,588,590.88	**61%**	
Public Service:							
Sponsored Programs	$ 41,256,878.52	$ 1,333,184.85	$ 467,945.00	$ 1,837,667.83	$ 44,895,676.20		**37%**
Federal Land Grant Appropriations (FFY21)	3,068,768.00				3,068,768.00		
State Extension Appropriations		13,079,166.00			13,079,166.00		
Subtotal Public Service:	$ 44,325,646.52	$ 14,412,350.85	$ 467,945.00	$ 1,837,667.83	$ 61,043,610.20	**37%**	
Construction:							
Sponsored Programs	-	-	-	-	-	**0%**	**0%**
Total Sponsored Programs Funding	**$ 111,673,221.87**	**$ 3,953,299.97**	**$ 2,055,964.11**	**$ 5,299,755.71**	**$ 122,982,241.66**		
Percent of Total Sponsored Programs	***91%***	***3%***	***2%***	***4%***	***100%***		***100%***
Grand Total of All Funding Per Category	**$ 117,620,239.87**	**$ 39,471,849.97**	**$ 2,055,964.11**	**$ 5,299,755.71**	**$ 164,447,809.66**		
Percent of All Funding	***72%***	***24%***	***1%***	***3%***	***100%***	***100%***	

Expenditures for the Period July 1, 2020 through June 30, 2021 (includes accruals)

	Federal	State of Idaho	Industry	Other	Institutional	Total	% of Grand Total	% of Sponsor Total
Instruction:								
Sponsored Programs	$ 2,133,162.85	$ 82,744.36	$ 21,261.49	$ 38,767.45	$ 259,463.96	$ 2,535,400.11		**2.1%**
	$ 2,133,162.85	$ 82,744.36	$ 21,261.49	$ 38,767.45	$ 259,463.96	$ 2,535,400.11	**1.4%**	
Research (Subject to HERD Survey Approval):								
Sponsored Programs	$ 48,268,657.93	$ 2,636,723.21	$ 1,793,858.61	$ 3,088,814.79	$ 9,360,525.88	$ 65,148,580.42		**54.2%**
Federal Land Grant Appropriations	2,751,780.92	-	-	-	-	2,751,780.92		
State Research Appropriations (CALS,FUR,IGS,EPSCoR)		21,412,033.72	-	-	-	21,412,033.72		
State Other Appropriations		7,106,608.53	-	-	-	7,106,608.53		
Other Sources	-	-	-	2,499,488.70	6,976,030.99	9,475,519.69		
Subtotal Research:	$ 51,020,438.85	$ 31,155,365.46	$ 1,793,858.61	$ 5,588,303.49	$ 16,336,556.87	$ 105,894,523.28	**60.0%**	
Public Service:								
Sponsored Programs	$ 40,244,987.75	$ 1,266,866.18	$ 327,820.59	$ 1,508,762.21	$ 9,265,323.74	$ 52,613,760.47		**43.7%**
Federal Land Grant Appropriations	2,895,783.95	-	-	-	-	2,895,783.95		
State Extension Appropriations	-	12,382,377.45	-	-	-	12,382,377.45		
Other Sources	-	-	-	-	167,016.08	167,016.08		
Subtotal Public Service:	$ 43,140,771.70	$ 13,649,243.63	$ 327,820.59	$ 1,508,762.21	$ 9,432,339.82	$ 68,058,937.95	**38.6%**	
Construction:								
Sponsored Programs	$ -	$ -	$ -	$ -	$ -	$ -	**0.0%**	**0.0%**
Total Sponsored Programs Funding	$ 90,646,808.53	$ 3,986,333.75	$ 2,142,940.69	$ 4,636,344.45	$ 18,885,313.58	$ 120,297,741.00		
Percent of Total Sponsored Programs	***75%***	***3%***	***2%***	***4%***	***16%***	***100%***		**100%**
Grand Total of All Funding Per Category	$ 96,294,373.40	$ 44,887,353.45	$ 2,142,940.69	$ 7,135,833.15	$ 26,028,360.65	$ 176,488,861.34		
Percent of All Funding	***55%***	***25%***	***1%***	***4%***	***15%***	***100%***	100%	

Detailed Allocations	
Library Support	
Graduate Research Assistantships/Research Associates	
Post Doctoral Fellows	
Technician Support	
Maintenance Contracts	
Research Equipment	150,000
Competitively Awarded Summer Research Support	
Start-Up Funds for New Hires	100,394
Incentives to Reward Faculty for Research Achievements	
Other	
Total Allocation	250,394.00

Detailed Allocations	
Publications in refereed journals	
Presentations at professional meetings and conferences	
Grants Received as a result	
Grants Pending	
Student Participation	
Faculty Participation	
Other Participation	
Patents Awarded	
Patents Pending	
Manuscripts Submitted	

Notes:
Research Equipment:
HPC (High Performance Computing) Equipment and Software - $117,000
Mainali Physics Lab - $33,000
TOTAL: 150,000

Startup
Cruz/Bittleston – Biology $100,394

($394.00 unused funds returned in FY22 from vivarium equipment funding in FY20)

TOTAL: $250,394

FY2022 IDAHO STATE UNIVERISTY INFRASTRUCTURE REPORT SUMMARY

ISU FY 2022	Total $	Detailed Allocations
Library Support	$0	
Graduate Research Assistantships / Research Associates	$0	
Post-Doctoral Fellows	$0	
Technician Support	$0	
Maintenance Contracts	$15,035	Compressor Service Plan for the N2 Compressor used identify steriods in plasma and tissue of animals. Service plan for the new Biology equipment to run samples.Onsite installation and training for the Amplifier Converter Modules.
Research Equipment	$114,882	Kitty Lohse, Danny Xu, Keith Weber 1) The Change out Station for Animal Facilities helps students, technicians and researchers in changing cages for injections animals are given for research purposes. 2) The computers bought for the GIS Center allows them to acquire, process and analyze much larger datasets including lidar and large volumes of satellite imagery. Biology recieved a key instrument to run samples of organic carbon, nitrogen and inorganic carbon. A new Millipore system was put in to produce pure water for making standards and reagents for biogeochemical analyses. YSI meters annd probes were purchased to measure stream pH, EC and conductivity on research on Reynolds Creek, Dry Creek and Gibson Jack, and the last thing purchased for Biology was an automated groundwater chemistry sampler that was used to investigate groundwater biochemical dynamics with changes in water table.
Competitvely Awarded Summer Research Support	$0	
Start-Up Funds for New Hires	$68,334	Curtis Billings - Audiology will use the equipment purchased for his lab for the study of neural effects of aging and hearing loss.
Incentives to Reward Faculty for Research Achievements	$0	
Other	$51,748	Project Suite software license, Lab Supplies
Total Allocation	$250,000	

FY2022 IDAHO STATE UNIVERISTY INFRASTRUCTURE REPORT SUMMARY

ISU FY 2022	
Publications in Refereed Journals	1) Uncovering the seasonal brain: Liquid chromatography-tandem mass spectrometry (LC-MS/MS) as a biochemical approach for studying seasonal social behaviors (accepted) Hormones and Behavior; Volume 142, June 2022, 105161 2)Advancement of liquid chromatography–mass spectrometry and its impact on high-throughput screening of protein/peptides (in preparation) 3) Identification and quantification of sesquiterpene lactones (SLs) of Sagebrush (Artemisia tridentate spp. tridentata) and its chemical modification (in preparation). Two Manuscripts are in preparation. 1 Manuscript in preparation for Kieth Weber. 4) 2 Manuscript are in preparation in Pharmacy.
Presenations at Professional Meetings and Conferences	1)INBRE - Biology, 2)1 presentaiton at the Idaho Conference of Undergraduate Research, 3) 2 presentations at the ARO national meeting and 1 presentation at a state/regional meeting: 2 additional presentations accepted at a national and regional meeting for Pharmacy
Grants Received as a Result	1) NSF-Biology, 2) 1 grant awarded by FEMA. 2) Mountain West CTR-IN Pilot Grant: Idaho NASA EPSCoR Research Grant.
Grants Pending	1) 2 grant proposal submitted and in review 2) American Hearing Research Foundation Discovery Grant
Student Participation	1) 1 student completed her MS thesis and a second student is working toward her Honors program/Senior thesis. 2) The Xu Lab trains 4 PhD students. 1 Master level student and 2 PharmD/PhD students.
Faculty Participation	1) Devaleena Pradhan (Biology), Kavita Sharma (Pharmacy), 2) 2 faculty/staff participated in research as a result of the computer workstation purchased. 3) The equipment purchased is used in the Xu Lab's zebrafish facility to support biomedical research by BPSCI Department Faculty.
Other Participation	NASA DEVELOP interns/visiting scholars used these workstations to complete their study with ISU GIS Center advisor.
Patents Awarded	None
Patents Pending	Several Provisional Patient filing in in preparation for Pharmacy with Dr. Danny Xu.

FY 2022 LEWIS-CLARK STATE COLLEGE INFRASTRUCTURE REPORT SUMMARY

	Total $	Detailed Allocations	
Library Support	$43,377	See next tab for detail.	
Qualtrics License	$7,508	Annual campus license for survey software for use by faculty students for their survey research.	
SPSS campus-wide licenses	$6,485	Statistical Package for Social Sciences (SPSS) for use by faculty in statistical research methods.	
Research Symposium	$10,000	Annual LC State Student Research Symposium	
Salary for Research Librarian	$36,631	Salary and fringe for LC State Librarian to support undergraduate and faculty research efforts.	
Total Expenditures	$104,000.00		

	Detailed Allocations	
Publications in Refereed Journals		
Presentations at Professional Meetings and Conferences		
Grants Received as a Result		
Grants Pending		
Student Participation	Students utilize the research librarian and the purchased library resources in coursework, undergraduate research activities, and in preparing for the annual LC State Research Symposium. For survey research, Qualtrics survey software was purchased using HERC Infratructure funds for studnets' use at no cost.	
Faculty Participation	Faculty utilize the research librarian, the SPSS and Qualtrics software products, the purchased library resources and assist students in preparing for the annual LC State Research Symposium.	
Other Participation	Community members, faculty and staff emeritus, and alumni are invited to attend the research symposium each year.	
Patents Awarded		
Patents Pending		

FY2022 Lewis-Clark State College Infrastructure Report details

FY22 HERC Infrastructure Funds: Library Expenses

$	12,711.73	EBSCO-Nature, England Online Journal 2021
$	5,884.06	EBSCO-Cell-Online Journal 2021
$	3,523.73	EBSCO – (AAAS, Science Journal) 2021
$	1,528.37	Infobase Learning – Technical & Trade Education Collection
$	2,039.18	Infobase Learning – Allied Health Collection
$	3,259.92	Infobase Learning – Nursing Video Collection
$	10,680.89	Infobase Learning – Master Academic College
$	3,749.25	Infobase Learning – Feature Films for Education
$	43,377.13	

FY 2022 UNIVERSITY OF IDAHO
INFRASTRUCTURE REPORT SUMMARY

	Total $	Detailed Allocations
Library Support	$0	
Graduate Research Assistantships / Research Associates	$0	
Post-Doctoral Fellows	$5,941	$3,916.84, Idaho Water Resources Research Institute PostDoc Fellow; $2,023.00, Membership in the National Post-doc Association and attendance to the national meeting for post-doc leadership
Technician Support	$17,058	$5,742.10, Electron Microscopy Service Center; $11,315.97, Optical Imaging Center.
Maintenance Contracts	$1,739	
Equipment	$80,443	$73,055.38, Research Computer and Data Services equipment upgrades; $7,387.56, chromatography refrigerator to store non-critical products such as reagents, media, and proteins and an ice machine as ice is needed to keep sensitive reagents/samples cool while working with them on the laboratory benchtopfor IRIC researchers.
Start-Up Funds for New Hires	$0	
Incentives to Reward Faculty for Research Achievements	$6,470	Excellence in Research Award
0	$138,350	$23,092.30 for EPSCor management payroll expenses; $50,915.58, funding for faculty to aquire additional research data to strengthen competitive proposal resubmissions; $2,321.50, UI PostDoc/Faculty Mentor Award; $10,000, publishing support; $5,403.03, cost share for developing thermostat prototype for holistic climate control system; $6,250.00 for feasibility study with detailed drawings and cost estimates for renovation to establish the Nutrition Analytics Core Laborator for the COBRE in Nutrition and Women's Health; $7,387.56 for building modifications to house the CAES NuScale Simulator; $6,493.53, refinish floors in the Lab Animal Research Facility; $10,721.72, Water Symposium; $14,913.35, upgrade Hagerman Fish Culture Experiment Station power backup; $3,296.53, AI workshop.
Total Allocation	$250,000	

FY 2022 UNIVERSITY OF IDAHO
INFRASTRUCTURE REPORT SUMMARY

	Detailed Allocations
Publications in Refereed Journals	7
Presenations at Professional Meetings and Conferences	22
Grants Received as a Result	3
Grants Pending	1
Student Participation	27
Faculty Participation	106
Other Participation	109
Patents Awarded	0
Patents Pending	0

NOTE: Other participation includes postdocs, research scientists, research specialists, UI administrative staff, industry partners and stakeholders. Tour attendees of CAES' NuScale Simulator included: podcast host; faculty and other representatives from University of Utah; UI VP of Research; city, county, state, and federal government representatives; ISU faculty, provost and dean; American Nuclear Society student chapters from BSU, UI, and Utah State University; West Wyoming Community College; 165 eight-grade young women and more than two dozen teachers participated in five workshops as part of INL's annual My Amazing Future; industry partners.

Higher Education Research Council
Undergraduate Research Fellows
Boise State University
Final Report

Academic Year 2021-2022

Donna Llewellyn, Executive Director, Institute for Inclusive & Transformative Scholarship
Nico Diaz, Senior Student Initiatives Coordinator, Institute for Inclusive & Transformative Scholarship

Introduction

The Institute for Inclusive & Transformative Scholarship oversaw the HERC Undergraduate Research Fellowship at Boise State University Fall 2021, and Spring 2022. HERC funds were used to support Boise State undergraduate students who had minimal research experience with a 10-week mentored research opportunity during the fall and spring semesters. Funds provided by the Higher Education Research Council supported a total of 17 students across 13 different STEM disciplines.

On behalf of the Institute for Inclusive & Transformative Scholarship, we thank the Higher Education Research Council for their generous support in helping build meaningful experiential learning experiences for Idaho students and supporting faculty research.

HERC Funding:

Stipends	**Amount**	**Details**
Fall Semester Research Stipends	$21,000	7 students at $ 3,000 each
Spring Semester Research Stipends	$30,000	10 students at $3,000 each
Total	**$51,000**	

The Higher Education Research Council provided $51,000 in funding to support STEM undergraduate research at Boise State University this year. Please see the table below of how stipends and travel awards were dispersed.

The titles and abstracts of the student projects are on the following pages.

Fall 2021 and Spring 2022 HERC Fellows
Research Projects

Fall 2021 Fellows

Benjamin Balzer - Molecular Biology

Title: Custom DNA Origami Scaffolds for Digital Nucleic Acid Memory
Abstract: Motivated by the continuous growth of data storage capacity the semiconductor memory materials are approaching their production limits. DNA has been selected as a valid alternative candidate due to its information density and long retention time. Here at the Nucleic Acid Memory Institute we developed digital Nucleic Acid Memory (dNAM), which uses DNA origami as a breadboard for data storage that provides a matrix of complementary strands that bind dye-labeled single stranded DNA (ssDNA). DNA origami is made from a ssDNA scaffold and short oligonucleotides (short ssDNA) that fold together into a predefined shape. The dNAM project currently relies on the M13 ssDNA scaffold which has a fixed length of 7.2 kilobase pairs (kb), limiting size and customization of the DNA origami. Ability to create larger scaffolds will expand the storage capacity and versatility of the DNA origami breadboard. In order to create larger scaffolds, we used a phagemid/helper phage system to produce ssDNA in bacteria and then export it from the cell. Using restriction enzymes cloning we produced a custom 11,054 base pair scaffold from previous ssDNA produced phagemids. Future project's perspectives are to increase yield of the scaffold production as long as its length and create a fully customizable sequence tool to expand the robustness and accuracy of dNAM.

Cameron Brown, Anthropology

Title: Dogs produce distinctive play pants: Confirming Simonet
Abstract: Identifying meaningful vocalizations in nonhuman animals can explain the evolution of human communications. However, non-speech like sounds, including laughter equivalents, are under-studied. The purpose of this pilot is two-fold: 1) we aimed to determine whether dogs perform a domain-specific pant during play, and 2) we sought to capture target vocalizations characterizable as a play pant, and compare them across three interactions: training, play, and rest. We defined the target vocalization as including frequencies between 0 to 4 kHz; lengths between 0.1 and 0.3 seconds; large, irregular oscillating waveforms and high amplitudes; and the absence of harmonic bands. Bonded human and dog partners participated in a session that included all three interactions. During these sessions, both partners wore wireless microphones that transmitted to a receiver and digital recorder, while a standalone digital camera captured video of the interactions. A total of 16 human-dog pairs participated. Using a one-way ANOVA, the results demonstrate that dogs do perform a domain-specific play pant, which was almost completely absent during training and rest. These findings suggest that a laugh like play pant is used by dogs during play, and that future research should explore other interspecific acoustic signals as communicatory.

Claire Conner, Early Childhood Special Education

Title: Teaching Professional Communication Skills to Undergraduate Students
Abstract: Effective communication is necessary for every profession (Hargie, 2016). Understanding how to facilitate dialogue is especially important for educators (Wei, Murphey & Firetto, 2018). Discussions help students understand course content, and effective professional communication is key to creating shared meaning with students, parents, and colleagues (Michaels & O'Conner, 2015). This study was conducted in the fall of 2021 to identify what interventions, including direct instruction, feedback, and self-assessment,

support undergraduate education students in developing their professional discourse skills. The researcher first conducted a literature review regarding communication and discussion skills. She then created a module that taught an overview of these skills. Lastly, she created a rubric to measure students' acquisition of the skills. She presented the module and rubric to the class as an online assignment at the beginning of the semester. Class participants then recorded biweekly small group discussions. The researcher scored each individual student on the created rubric and met with students after each session to review the rubric and provide feedback on their performance. Students also completed a brief self-assessment form after each discussion. Utilizing the rubric, the researcher tracked student progress across six criteria over six small group discussions. The data show improvements in scores across all domains, with the largest proportional increase after the first two feedback sessions. The class participants completed an optional survey at the end of the semester that indicated students felt the four interventions: module, rubric, self-assessment, and individual feedback sessions, were either very or somewhat beneficial (with the expectation of two out of eighty responses). Out of all the interventions, students indicated that the individualized rubric is the best to incorporate into future courses. The researcher created a rubric and module template for faculty interested in incorporating professional discourse skills into their coursework, as the majority of these skills are generalizable across contexts.

Allison Kurtin, Political Science

Title: Civil Liberties in Latin American Prisons: The Effect of the Coronavirus Pandemic and Government Responses

Abstract: "This paper establishes a correlation that explains COVID-19 mitigation measures in Latin American prisons, utilizing data collected for each country, as well as two case studies. Some Latin American countries have been notorious for poor prison conditions and limited protection of civil liberties for persons deprived of their liberty. I expect that the countries with better conditions will implement more effective strategies to prevent the spread of COVID-19 in prisons. In this paper, I collect data that represents both countries' protection of civil liberties prior to the pandemic and the level at which that same country implements strategies to mitigate the spread of COVID-19. The data collected shows a weak positive correlation between these two factors, supporting the thesis that countries that protect prisoners' civil liberties will also attempt to protect them from COVID-19. Two case studies are also included in this paper to provide supporting evidence for the research topic. First, I provide a case study of Venezuela, a country notorious for poor civil liberties protections and prison conditions. I find that Venezuela also implemented very minimal COVID-19 mitigation measures. The second case study is on Chile, in which the government and democracy is a bit stronger than other Latin American countries. Based on the categories discussed in the data section of this paper, Chile scored the highest score possible for implementing COVID-19 prevention strategies in prisons. The data collected and analyzed and the two case studies work together to support the thesis of this paper that countries that effectively protected civil liberties of prisoners prior to the pandemic also effectively protected them during the pandemic. On the other hand, countries that poorly protected prisoners would not successfully implement strategies to combat the pandemic in prisons.

Kyle LaCoursiere, Geosciences

Title: How does inter-annual snowpack variability impact reservoir storage in the Magic Reservoir?

Abstract: Water users in the state of Idaho are dependent on reservoir storage for irrigation during the dry season. By knowing the reservoir storage early water users can decide on how much water to use and when to use it. We want to predict reservoir storage so that water users can then have early access to the upcoming

storage levels and can then decide the action needed in using the predicted reservoir storage. To predict reservoir storage, we used a linear regression automated model selection that highlighted the important variables of Spring temperatures, Winter temperature at Soldier R.S. SNOTEL site, and Snow Water Equivalence (SWE) at Camas Creek Divide SNOTEL site. The model found that these variables are the major drivers of predicting maximum reservoir storage at Magic Reservoir in Idaho. The implication of this finding is that spring temperatures play a larger role in prediction reservoir maximum storage than Snow Water Equivalence. This is impactful as spring temperatures are not thought of as a major driver in predicting reservoir maximum storage, when in accordance with the results shown from this study spring temperatures are a major driver in predicting reservoir maximum storage.

Anna Shuey, Biology

Title: Effects of doxorubicin on autophagy in fibroblasts

Abstract: "NOTE: This is a work in progress. We have changed some aspects with further research and wanted to add some data that has just been collected as part of the ongoing project since the HERC fellowship was awarded. I plan to present at the summer ICUR event on behalf of HERC. I hope this will work for this purpose and a finalized version will be presented later in the summer at ICUR. Doxorubicin is a highly effective chemotherapeutic used to treat many adult and pediatric cancers, such as solid tumors, leukemia, lymphomas and breast cancer. However, its use is limited due to a dose dependent cardiotoxicity, which can lead to lethal cardiomyopathy. It is generally accepted that the principle mechanism is oxidative stress induction through the production of reactive oxygen species (ROS) and free radicals in the myocardium. The increased level of oxidative stress can subsequently induce apoptosis and cell death in cardiomyocytes. Efforts to reduce/prevent doxorubicin toxicity using antioxidants have largely failed in pre-clinical and clinical trials, indicating that oxidative stress may only partially explain the cardiotoxicity. Thus, novel mechanisms responsible for doxorubicin cardiotoxicity and intervention measures targeting these novel mechanisms need to be explored in order to expand the use of this effective anticancer drug. Fibroblasts are the largest cell population in the heart and play a critical role in normal cardiac function. Cardiac fibroblasts are the main cell type responsible for the synthesis, deposition, and degradation of cardiac extracellular matrix (ECM). Cardiac ECM not only provides structural support for cardiac cells, but also plays important roles in electrical signaling, secretion of growth factors and cytokines, and potentiating blood vessel formation. In contrast to extensive research efforts on toxic effects of doxorubicin in cardiomyocytes, data on the effects and mechanisms of doxorubicin on cardiac fibroblasts and ECM homeostasis are limited. Autophagy is molecular machinery for “self-eating” in cells. It is a highly conserved process of self-degradation of cellular components in response to extra or intracellular stress and signals such as starvation, growth factor deprivation, and pathogen infection. Autophagy are involved in many disease conditions. The goal of this study is to examine the effects of doxorubicin on autophagy in cardiac fibroblasts. The results of this study further our understanding of mechanisms of doxorubicin-induced cardiotoxicity, which may lead to novel intervention measures that target these key signaling events, and ultimately improve therapeutic options for cancer treatment. Through use of cell culture, western blotting, and PCR techniques, we have been able to gain new knowledge into the effect of doxorubicin on autophagy by the monitored expression of known autophagy biomarkers P62 and LC3B. Preliminary western blot data has shown that both P62 and LC3B expression are reduced in the NIH 3T3 cell line, which indicates increased level of autophagy. A similar trend was not obvious in primary cardiac fibroblasts, suggesting fibroblasts from different origins may respond to doxorubicin treatment differently. Our preliminary results suggest that doxorubicin has an effect on

autophagy within fibroblast cells, although perhaps to differing degrees for different cell lines, and this could be a potential mechanism to explore in preventing doxorubicin-induced cardiotoxicity with further study.

Claire Vaage, Environmental Sciences

Title: Delineating riparian vegetation using remotely sensed data: a variable width model from the Boise foothills

Abstract: Riparian vegetation is critically important for dryland ecosystem functions including maintaining water temperatures for resident fish populations, enhancing carbon sequestration, stabilizing stream banks and flow, and supplying and retaining nutrients within water systems. Development of management and conservation strategies for these vital areas is dependent on mapping the extent of the characteristic riparian vegetation. The primary step in modeling hydrological ecosystem dynamics includes defining the riparian buffer through fixed-width or variable-width approaches. Fixed-width buffers do not accurately capture smaller, unique riparian areas because they only account for the watercourse, ignoring inputs such as stream order or geomorphology. A variable-width buffer reflects spatial variability in riparian vegetation by accounting for landscape complexities, such as fine-scale variation in topography that complicate proper estimations of riparian zones. Using a 1-m spatial resolution digital elevation model (DEM) derived from aerial lidar, we mapped the stream network of the southwestern section and lower elevations of the Dry Creek Experimental Watershed in Idaho, USA. This watershed encompasses a topographically complex/diverse ecosystem gradient, from sagebrush steppe to evergreen forest. Then, we generated random points along the predicted stream network to digitize (n = 1,500) and ground truth (n = 150) riparian vegetation. We developed a regression model to predict riparian vegetation width using the collected digitized and ground truth measurements, and additional covariates (i.e., slope, aspect, elevation, vegetation). Our results provide a way to accurately map riparian buffers in sagebrush steppe ecosystems through a novel variable-width approach and allow for additional research on the geomorphological, hydrological, and ecological characteristics of riparian areas within drylands.

Shuai (Sharon) Yang, Computer Science

Title: Profiling Hate Speech Spreaders on Twitter

Abstract: Hate speech is defined as any public communication that depreciates a person or a group by expressing hate or encouraging violence. From the identification of the profiles of hate propagators, it is possible to avoid the spread of hate speech and keep social networks healthier. In this study, I focused on Twitter. Simply analyzing words in tweets is a good starting point to identify hate speech and people who spread hate speech. However, we believe there is value in considering other expressions that are commonly seen in tweets. The purpose of this study was to explore a variety of expressions and unveil a set of common patterns that could lead to identifying user profiles that promote hate speech on social media (Twitter).

Spring 2022 Fellows

Cooper Conway, Political Science

Title: Per-Pupil Spending and Population Numbers Effects on ISAT Proficiency A Multiple Regression Analysis

Abstract: The stagnation of student performance in America has been linked to many factors. The primary explanations for the stagnation usually vary between the amount of per-pupil spending in America's K-12 system and outside factors such as culture and family (Coleman et al.,1966; Hanuschek, 1984). Newer research has used isolated increases in per-pupil spending at the local, state, and national levels to analyze the effects spending has on student outcomes (Baron, 2019; Carolyn, et al, 2020). The researcher in this study took a different approach using existing data pulled from the Idaho State Department of Education and the Reason Foundation to run a multiple regression analysis in IBM's Statistical Package for the Social Sciences (SPSS). The output from the multiple regression explained the relationship

Fall 2021 and Spring 2022 HERC Fellows
Research Projects

between per-pupil spending and population numbers on math proficiency rates among economically disadvantaged eighth-graders on the Idaho Standards Achievement Test (ISAT). The researcher's findings indicate a negative relationship between per-pupil spending and the amount of economically disadvantaged eighth-graders on ISAT Math proficiency rates among economically disadvantaged eighth-graders. However, the percentage of economically disadvantaged eighth-graders in each district has a moderately strong negative relationship with math proficiency rates leading the researcher to believe outside factors such as family and cultural values may have a stronger relationship regarding economically disadvantaged student outcomes in Idaho.

Hannah Hedelius, Psychology

Title: Idaho Humane Society Workshop
Abstract: The Idaho Humane Society previously had a workshop for middle school students, however it was short in time and lacked essential topics including Fear Free handling and animal body language. Educating students on these topics is important for the care and safety of both animals and humans. We created a 2-hour Junior Vet Tech workshop and presented the curriculum using PowerPoint, animal observations, technique demonstrations, and available practice time. This increased both the interest in learning more about animals but also interest in volunteering at the Idaho Humane Society.

Alejandra Hernandez, Health Sciences

Title: The Importance of Community for a Study Examining Pesticide Exposure and Risk Perceptions Among Latinx Farmworkers
Abstract: Latinx farm workers make up over 80% of the United States farmworkers, and research has shown they have high levels of exposure to pesticides. Studies have also shown females are at risk for higher levels of pesticide exposure. The purpose of the overall study is to examine pesticide exposure and risk perceptions among male and female Latinx farmworkers. Here, I describe the importance of community when working with structurally marginalized populations like Latinx farm workers. The purpose of presenting this component is to give researchers an understanding of why creating trust and getting the respect of the communities that are being researched is so important. In addition, this will give researchers ideas as to how their research project can be more collaborative and include the community that is participating in the study. In this case, we have forged partnerships with multiple trusted community partners and organizations in order to recruit study participants, address potential power dynamics inherent in many research studies, and ensure this research provides a benefit to participants. Following the conclusion of the study, we will partner with Boise State's Project SCIENTIA to create multi-media science communication products to translate the study findings and recommendations to participants and groups supporting farmworkers.

Andy Lee, Physics

Title: Projection Effect of Galaxy Clusters
Abstract: Dark matter halos are used as cosmological probes of the universe. From the halo mass function, we can obtain energy density parameters. However, in the observation of halos there are projection effects that make it difficult to count the number of galaxies in a halo. These projection effects include uncertainty about the radius of each halo and the line of sight distance. The line of sight distance is measured from the halo center. Distances are determined with redshift. We can use simulation data so we know everything about a halo and then compare different methods of counting galaxies. For simplicity, we used a fixed line of sight distance and assumed we knew the halo center. We compared galaxy counts from catalogs using different line of sight distances, with and without percolation, and fixed vs iterative radii. Percolation is counting a galaxy towards the more massive halo when the galaxy is within the radius of multiple halos to prevent halo radii from blowing up. The catalog without percolation has more galaxies at low masses but has little effect at high halo masses. We have found that the projection effects are dominated by galaxies within 15 Mpc/h.

Fall 2021 and Spring 2022 HERC Fellows
Research Projects

Marissa Maldonado, Mathematics Education

Title: Analysis of Undergraduate Mathematics Coursework for Curriculum Design
Abstract: Andragogy is the study of adult education and is an area of research that is neglected within university environments. There is a lack of curriculum/documentation analysis relative to increasingly modern formats of upper-division mathematics courses by use of technology and real-world applications. In finding proper modes of transportation for abstract mathematical concepts, teachers can make more informed approaches to teaching and developing curriculums at a university level. A case study will be conducted that compares the final group projects of a mathematical modeling course in alignment with assignment instructions, available documentation, and recorded lectures. This case study will give insight into how epistemology can be implemented into advanced, abstract mathematics courses for adult learners.

Cooper McGrath, Biology

Title: aBRCAdabra! Cytokines Make DNA Repair Disappear in Breast Cancer
Abstract: Approximately 1 in 8 women will be diagnosed with breast cancer in their lifetime. For a localized breast cancer, the five-year prognosis is 99%, but for metastatic breast cancer the five-year prognosis has remained an abysmal 27%. Proteins called cytokines have been found in abundance in breast cancer tissue and have been shown to increase the metastatic potential of breast cancer cells. Cytokines accomplish this by means of altered gene expression through their signaling cascades, but the role of cytokines in regulating the expression of genes associated with DNA repair is understudied. BRCA1, BRCA2, and BARD1, are tumor suppressor genes, that function in DNA repair of double stranded breaks. Regulation of these genes through cytokine signaling may lead to decreased DNA repair in the breast cancer cells, an increase in epithelial to mesenchymal transition (EMT), and a worse prognosis for cancer patients. Quantitative reverse transcriptase-polymerase chain reaction (qRT-PCR), and western blot analysis, was used to measure BRCA1, BRCA2, and BARD1, expression after treating breast cancer cells with cytokines, in vitro. Establishing a connection is important, as it could lead to physicians designing therapeutic plans that target BRCA deficiencies for patients with high levels of these specific cytokines, in turn leading to a better outcome for patients.

Ace Pedraza, Biology

Title: How does prey type affect pitcher plant, Sarracenia purpurea, microbial community function?
Abstract: Microbial communities are formed by groups of microorganisms, which impact the earth's ecosystems. The way these organisms interact and function significantly affects how nutrients and energy move through our ecosystems. Discovering, analyzing, and defining the functions carried out by microbial communities can help reveal how ecosystems shift with changing conditions. However, it's a challenge to analyze and track microbial community interactions or functions within large ecosystems. Focusing and analyzing the microbial communities in small ecosystems first, will help to study larger ecosystems. This study uses the small-scale ecosystem of the carnivorous pitcher plant, Sarracenia purpurea, to investigate microbial community functions in the plant's digestive fluid. The microbial organisms found in the pitcher's digestive fluid help with the decomposition of captured insect prey. This study worked on answering the question: how does prey type affect pitcher plant, Sarracenia purpurea, microbial community function? Four different insect prey types and an inoculant of bacterial communities originally isolated from three wild pitchers were used to simulate a pitcher plant ecosystem in glass tubes. Analyses of enzymatic tests and substrate utilization revealed how different insect prey affect microbial community functioning. The results show a significant difference in the microbial community function for the different insect prey. Different insect prey affects the pitcher plant's microbial community function in chitinase, protease, and substrate utilization across 31 distinct compounds. Future studies will expand on other areas of microbial community function that affect how insect prey is digested in pitcher plants.

Matthew Robinette, Mechanical Engineering

Title: Impact of age and surface on lower limb muscle activity during walk and pivot tasks

Fall 2021 and Spring 2022 HERC Fellows
Research Projects

Abstract: Muscular strength decreases with age leading to changes in lower limb muscle activity, such as increased agonist and antagonist co-contraction, during gait task older adults (over 65 years). External perturbations, including cognitive distraction and slick surface, challenge the central nervous system, resulting in muscle activity alterations to safely walk.1,2 Yet, it is unclear whether older adults exhibit greater alterations in muscle activity than young adults during gait task with challenging perturbations.

Ellie Schlake, Electrical Engineering

Title: Laser Sintering of Flexible Electronics
Abstract: Printed electronics allow for flexible and durable devices called flexible hybrid electronics (FHE). The flexible capabilities of FHE make them suitable for conformable biosensors, allowing movement and comfortability, real-time and non-invasive sensing. Direct-deposition printing of inks or colloidal suspensions is the primary process in FHE fabrication to produce various device features on flexible substrates. Unfortunately, printing technologies do not provide a consolidated thin film of the desired material; but only deliver the ink in nanoparticles or nonconductive clusters. Printing processes must be assisted with a high-temperature and time-consuming post-processing treatment to obtain desired material properties. Laser sintering is an alternative post-processing method to sinter nanoparticles. Laser sintering is sensitive to laser parameters such as power, intensity, wavelength, scanning speed, pulse duration, and sample parameters such as absorption cross-section, film composition, film thickness, substrate, and substrate temperature. By varying these parameters, attempted sintering of gold (Au), platinum (Pt), and silver (Ag) were done using a laser. The results demonstrate the effectiveness of laser sintering to achieve desired electrical properties of printed metallic films. We anticipate laser sintering as a method for metallic inks with excellent electrical properties and are susceptible to oxidation, expanding FHE applications.

Gwen White, Material Science and Engineering

Title: Patching Force Fields of Organic Materials through Open Scientific Software Development
Abstract: Solar cells made from organic photovoltaic (OPV) materials have the potential to provide sustainable solar power generation due to their low manufacturing cost and processability. Molecular dynamics (MD) simulations allows for the pre-screening of OPVs. Doing so requires the description of interaction potentials between simulation elements. of the thermodynamic self-assembly of new OPV compounds more efficiently than wet lab experiment, by modeling molecules with interactions specified by a "force field". The first step of simulating a new compound in MD is deciding how to apply forcefield parameters based on the chemical structure of the molecule, and if the chemical environment is not defined in the forcefield, then new parameters must be created. Here we develop and use computational tools for identifying bond, angle, and dihedral constraints that are missing from a forcefield, and perform quantum chemical calculations to parameterize these missing components. We set up the QUBEKit software stack on the Borah high performance computing (HPC) cluster, utilize SMILES strings to specify minimal molecular snippets, and parameterize models of Y6 and BTO, which have recently demonstrated power conversion efficiency over 17%.

TO: Idaho SBOE HERC

FROM: Deb Easterly, Ed.D, Asst. VP for Research

DATE: December 1, 2022

RE: ISU FY 22 Undergraduate Research SBOE HERC Funds Report

In FY 21 year ISU instituted a new process to spend the SBOE HERC undergraduate research funds. In *The Undergraduate Experience* (2016), the authors state, "undergraduate research is a process that, at its best, moves students to new levels as learners and inquirers. The relationship between mentor and protégée can be transformative because it is rooted in an ongoing, substantive interaction around an essential part of the academic enterprise, scholarly research" (p.48). This was the guiding theme of the program for this year. Awards were made to six projects that included 2-3 undergrad students each. Attached reports from students and faculty describe successful mentoring experiences. Faculty were from Biological Sciences, Math, Civil Engineering, Psychology, Computer Science and Mechanical Engineering.

Seventeen students were involved in the above-described process. Thirteen students were awarded travel funds to attend research conferences across the country. Three students presented posters at the National Conference on Undergraduate Research.

$10,000 was awarded to the ISU McNair project to assist with attendance at conferences to make presentations and conduct research projects. The remaining $1200 that was not spent out of the $10,000 was awarded to one of the 6 funded faculty projects.

Three students received partial funding to attend the Belize Valley Archaeological Reconnaissance Project. The BVAR Project has been conducting archaeological research in central Belize since 1988 with the initiation of excavations at the ancient Maya site of Cahal Pech. Cahal Pech and Baking Pot are among the largest prehistoric Maya sites in the upper Belize River Valley and served as the capitals of medium-sized kingdoms in the Classic period (ca. AD 250-900).

The ISU Undergraduate Research symposium was held in-person after 2 years of being online because of Covid. Thirty-two students participated. The abstracts of their posters are attached.

Nineteen ISU undergrads presented at the 2021 ICUR.

See the link below for reports on individual projects, including posters that were presented by students.

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Prepared by Deb Easterly, EdD, Assistant VP for Research, Idaho State University

FY22 Lewis-Clark State College Undergraduate Report

Student Name	Advisor	Project	S/Y	Amount Requested Supplies/Travel	Amount Requested Salary	Total
A. Marler	E. Stoffregen	Analysis of the Effects of Blm-deficient Development on Long-Term Biological Outcomes	Semester	$0	$7,200	$7,200
K. Freeman	E. Stoffregen	Analysis of the Effects of Blm-deficient Development on Long-Term Biological Outcomes	Semester	$0	$7,200	$7,200
K. Lockett	E. Stoffregen	Long-Term Biological Consequences of Blm-deficiency During Early Embryonic Development in Drosophila Melanogaster	Semester	$1,150	$0	$1,150
B. Graves	E. Stoffregen	Long-Term Biological Consequences of Blm-deficiency During Early Embryonic Development in Drosophila Melanogaster	Semester	$1,150	$0	$1,150
B. Robinson	M. Brady	Competitive Interactions Between the Native House Finch (Haemorhous Mexicanus) and the Non-Native House Sparrow (Passer Domesticus)	Semester	$900	$1,008	$1,908
E. Cowdrey	J. Savage, C. Robinson	Lower Body Biomechanics of Post-surgical Knees and Healthy Knees During Single Leg Hops	Year	$180	$600	$780

FY22 Lewis-Clark State College Undergraduate Report

S. Eberley	L. Latta	Effective Antimicrobial Agents in Chlorhexidine Gluconate 0.12% on Multiple Bacterial Species of the Mouth	Year	$0	$936	$936
T. Frei	J. Savage, C. Robinson	Lower Body Biomechanics of Post-surgical Knees and Healthy Knees During Single Leg Hops	Year	$180	$600	$780
R. Hull	K. Allison	An Exploration of How Nursing Students Engage in LGBTQ+ Healthcare	Year	$0	$3,800	$3,800
C. Kauffman	C. Addo-Quaye	A Novel Clustering Algorithm For Mutant Comparative Genomics	Year	$0	$1,600	$1,600
K. McCown	L. Mataka	Optimizing the Extraction Methods of Biomolecules From Natural Products	Year	$0	$2,400	$2,400
H. Sellmann	L. Latta	The Relationship Between the Behavior of Daphnia magna and the Composition of their gut microbiota	Year	$0	$2,352	$2,352
						$31,256
Total						

FY22 Lewis-Clark State College Undergraduate Report

Amount Awarded Supplies/ Travel	Amount Award Salary	Dissemination	Other Outcomes
$0	$5,040	ICUR, HERC, LCSC Research Symposium	
$0	$5,040	ICUR, HERC, LCSC Research Symposium	
$1,150	$0	ICUR, HERC, LCSC Research Symposium	
$1,150	$0	ICUR, HERC, LCSC Research Symposium	
$900	$1,440	ICUR	
$180	$780	Northwest American College for Sports Medicine (NACSM), Western Society for Kinesiology and Wellness (WSKW), ICUR	

FY22 Lewis-Clark State College Undergraduate Report

$0	$1,080		
$180	$780	Northwest American College for Sports Medicine (NACSM), Western Society for Kinesiology and Wellness (WSKW), ICUR	
$0	$4,160	ICUR	
$0	$2,400	ICUR	
$0	$2,940	ICUR	
$0	$2,600	ICUR	
$3,560	$26,260		

STRATEGIC INITIATIVE
Undergraduate Research Funding for STEM Majors at the University of Idaho
FINAL PROJECT REPORT

Submitted to:
Higher Education Research Council
Idaho State Board of Education
P.O. Box 83720
Boise, Idaho 83720-0037

Submitted by:
University of Idaho Office of Undergraduate Research
875 Perimeter Drive
Moscow, ID 83844
November 18, 2022

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Executive Summary

Undergraduate research is recognized as a high-impact educational practice that increases the rates of student retention and engagement. At the University of Idaho, it is practiced throughout all units on campus, and it is centrally placed in the institution's strategic plan. The Office of Undergraduate Research is taking the lead in enabling research opportunities for undergraduates at UI. It manages various competitive student grant programs that directly support student research.

During AY 2021-22, generous funding from the State Board of Education permitted UI to continue its Summer Undergraduate Research Fellowship (SURF) Program. This intensive multi-week summer research experience actively engages undergraduates in faculty- mentored, independent research. Over the course of 10 weeks, students are mentored toward increased independence on their projects. Each student is provided with a $4,000 stipend in the form of a fellowship which allows them to devote full time effort to their projects. Each student is also provided with up to $1,000 to help offset materials and supplies and other project-related expenses based on budget requests and justifications. Selection of student participants is a competitive process in which students submit research proposals to the Office of Undergraduate Research. State Board of Education funding supported 13 SURF awards and our Gen Ed funding supported another 7 during the summer of 2022. Enclosed in this report are Titles, Abstracts, Accomplishments, and Budgets of 18 of the 20.

Funding provided by the State Board of Education also allowed the Office of Undergraduate Research to support several undergraduate researchers during the academic year. This was accomplished through competitive Undergraduate Research Grants awarded to students during the spring semester of 2022. These grants supported semester-long research projects under the guidance of faculty mentors. These grants were in the amount of $1,000 each for materials and supplies and other project-related expenses. For Fall of 2022, five projects were awarded funding. Names and titles for those five are also included. Those students will be required to present their research accomplishments at the April 2023 OUR symposium.

UI students supported by State Board of Education funds attended and presented the results of their projects at the 2022 Virtual Idaho Conference on Undergraduate Research held in Boise in July of 2022. These students will also be required to present their results at the UI Undergraduate Research Symposium in April 2023. Most significant about these awards are the many colleges that they touch. More than just the STEM colleges (College of Science, COS; College of Engineering, COE), these awards went to deserving students in the College of Letters and Social Science (CLASS), the College of Agriculture and Life Sciences (CALS), the College of Natural Resources (CNR), and the College of Education and Health and Human Sciences (CEHHS). End-of-project feedback from students and their mentors was overwhelmingly positive. Significantly, none of the undergraduate research projects described here would have been possible without the support provided by the State Board of Education. We sincerely thank the Higher Education Research Council and the Idaho State Board of Education for making these experiences possible for our students.

As for my role, I took on the task of Acting Director in the Fall of 2022 after working with the OUR for six years serving as the one Faculty Associate. We have now grown to have Faculty Associates in all Colleges (that feature undergraduates) and we are increasing our visibility to students in anticipation of growing the undergraduate research community and the distinction that undergraduate research brings to students.

Kristopher V. Waynant
Acting Director of the Office of Undergraduate Research
Assistant Professor of Chemistry
kwaynant@uidaho.edu

Final Project Reports: Office of Undergraduate Research (OUR) Undergraduate Research Grants
SURF 2022

Fellowship Recipient: Taylor Booker

Faculty Mentor: Sarah Wu, Dept. of Biological and Chemical Engineering, COE

Project Title: Evaluating a green nitrogen fertilzer produced by plasma discharge of air and water

Abstract:
Plasma activated water (PAW) has been identified as a green fertilizer and disinfectant. A new approach for improving crop yield and growth with an emerging PAW production method will be tested in this study. The objective of this study is to quantify seed germination and plant growth after repeated treatment with plasma activated water produced by a novel continuous flow liquid-phase plasma discharge (CLPD) reactor system. Optimal CLPD operating conditions for plant growth pertaining to nitrogen fixation with air and water will be determined. The findings from this study will help us to determine which plasma treatment time and power usage will be optimal for plant germination and growth and maximize yield, in order to develop CLPD produced PAW into a viable green fertilizer.

Project Accomplishments:

- Germination rate did not change with the addition of plasma reacted water
- Root and Stem Length varied for each plant regardless of whether they received treatment or not.
- Plant quality was not altered with treatment
- Treatment did not alter *Medicago Sativa* growth

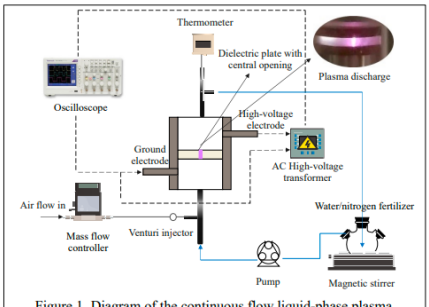


Figure 1. Diagram of the continuous flow liquid-phase plasma discharge reactor (CLPD) system

Summary of Budget Expenditures:

Description	**Cost**
Lab supplies:	
4 boxes of Nitrate TNTplus Test Vials (0.2-13.5 mg/L NO_3-N)	$188
4 boxes of Nitrite TNTplus Test Vials (0.6-6.0 mg/L NO_2-N)	$162
4 boxes of Nitrate TNTplus Test Vials (5-35 mg/L NO_3-N)	$188
4 boxes of Nitrite TNTplus Test Vials (0.015-0.600 mg/L NO_2-N)	$162
Sprout seeds	$100
Air filters, $TiSO_4$ reagent, H_2O_2 standards, and other chemicals	$110
Miscellaneous	$15
UI Undergraduate Research Symposium Poster	$75
Total	**$1000**

Acknowledgement: This work was made possible by generous support from the Idaho State Board of Education which provided the funding for this work and the UI's Office of Undergraduate Research.

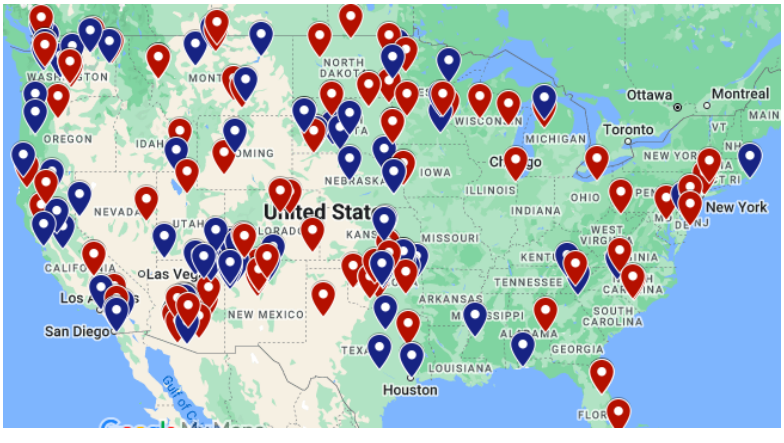
Fellowship Recipient: Christina Briggs-Mathers

Faculty Mentor: Omi Hodwitz, Dept. of Culture, Society and Justice, CLASS

Project Title: Missing and murdered indigenous women, girls, and Two-Spirit (MMIWG2) database

Abstract:
There is an epidemic of missing and murdered Indigenous women, girls, and Two-Spirit people (MMIWG2).[1] In the United States, we know little about this phenomenon. Academics have largely overlooked this issue, leaving it in the hands of the Indigenous population to collect information about MMIWG2 (King & Hodwitz, 2020). The problem with this is that the information tends to be scattered across a lot of different databases managed by various organizations. Sovereign Bodies Institute or Justice for Native Women are just two of the organizations led by Indigenous community members that collect the data on MMIWG2. There needs to be a single database that is exhaustive and accurate to create a foundation upon which to work when looking into this very important problem. This need is addressed by the MMIWG2 database, a project scheduled to begin in the summer of 2022 at the University of Idaho.

[1]Two-Spirit is a term for individuals who do not identify by the gender binary used by Indigenous communities.



Project Accomplishments:
The growing set of coded cases suggests a few key trends. First, most of the cases originate on the west side of the country, illustrating the importance of location. Second, the police do not have high closure rates and the cases they do solve usually involve a perpetrator that is already known to the victim. Third, the victims are more likely to be female and the perpetrators are more likely to be male.

Summary of Budget Expenditures:

Purpose	**Amount Requested**
Supplies, Services, and Other Materials (UI Symposium Poster)	$75
Total Amount:	$75

Acknowledgement: This work was made possible by generous support from the Idaho State Board of Education which provided the funding for this work and the UI's Office of Undergraduate Research.

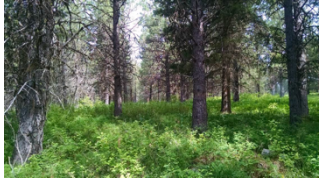
Fellowship Recipient: Bailey Briggs

Faculty Mentor: Mark Coleman, Dept. of Forestry, Rangeland, and Fire Sciences, CNR

Project Title: Nitrifier Abundance and Nitrification Rates in Reclaimed Water Irrigated Forest Soils

Abstract:
Pristine forests are nitrogen limited with conservative nutrient cycles, although anthropogenic nitrogen (N) inputs cause many ecosystems to saturate and lose N to the surrounding environment, causing an increased risk of leaching and eutrophication in freshwater ecosystems. The effects of nutrient additions are being studied in a time-series of five forest water reclamation facilities operating in Northern Idaho with treatment durations ranging from 9 to 44 years. This time-series presents an opportunity to compare microbially controlled nitrification processes. Insight into sustainable forest wastewater application has the potential to allow greater rates of carbon sequestration and increase water quality in surrounding freshwater systems. Nitrifying bacteria and archaea oxidize ammonium from wastewater to nitrate, which is highly mobile in soils. The rate-limiting step of nitrification is catalyzed by ammonia monooxygenase. Ammonia monooxygenase is encoded by the amoA gene, which can be used to detect presence and abundance of nitrifiers. Using qPCR amplification of amoA, the abundance of nitrifiers across the time series of forest water reclamation facilities can be compared to adjacent non-treated control plots. Comparing the respective nitrification rates and amoA abundance between treated and control plots can help determine critical nitrogen saturation and subsequent leaching risk.

Project Accomplishments:



Bailey's project was selected to be presented alongside her advisor in a "paired research presentation" at the ICUR 2022. She and her advisor, Mark Coleman each gave 10-12 slides each on the nitrification project.
Her conclusions for her project were:

- Forest Water Reclamation increases forest productivity
- Regulating wastewater application in spring and fall will decrease hydrologic losses during season
- Nitrate leaching occurs with age, indicating nitrogen saturation

A Final Focal Question was: Are there tools to measure nitrogen saturation?

Summary of Budget Expenditures:

Undergraduate Research Symposium poster	*$75*
Zymo soil DNA isolation kit, 100 extractions	*$37**
amoA primers	*$52*
qPCR plates and covers	*$396*
Microbe-Lift, nitrifying culture	*$12*
SYBR Mastermix, 500 reactions	*$428*
Total	*$1,000*

Acknowledgement: This work was made possible by generous support from the Idaho State Board of Education which provided the funding for this work and the UI's Office of Undergraduate Research.

Fellowship Recipient: Melinda Cross

Faculty Mentor: Kattlyn Wolf, Dept. of Agricultural Education, CALS

Project Title: Development of Effective Marketing Strategies based on Consumer Perspectives of Junior Livestock Shows and Sales

Abstract:
A buyer's perspective and reasoning for their decisions is constantly changing, and often hard to predict. In order to keep up with and try to cater to the buyers, it is crucial that inquiries are made regarding their thought processes. From scholarship opportunities to community involvement--Junior livestock shows offer numerous benefits to both the producer and consumer. Unfortunately, there is little research on the subject of buyer demographics and what motivates them. Recently, there has been a decline in consumer support of livestock shows and sales. In this study, surveys and interviews will be conducted to better understand the consumer's perspective as well as their knowledge on the livestock showing industry. This information will be put to use in an experimental marketing campaign for the Latah County Livestock Show. The finding of this study will be used to discover effective marketing practices for this particular industry.

Project Accomplishments:
From interviews of all current and past buyers the data suggests that a later sale time was motivating in addition to providing thank you cards and actual stories from children who discuss their projects. There was a lack of knowledge in the county on what exactly 4-H and FFA were promoting or doing and therefore a lack of community support. We expect to improve the Latah Market Animal sale in the future by moving the sale to a later time, offering a buyer's luncheon, and asking for buyers to sign-up ahead of time to make time in the livestock show and sale more efficient.

Summary of Budget Expenditures:

Item (Qty)	Justification	Cost
Incentives for survey respondents/interview participants	Incentives for survey completion (i.e. stickers, online coupons, etc.)	$300
Exhibit at Latah County Fair	Prizes, Posters, Brochures, etc.	$350
Meeting Information	Posters. Brochures, Photos, Possible Recruitment of Business owners to chat with the kids.	$350
Total Budget		$1000

Acknowledgement: This work was made possible by generous support from the Idaho State Board of Education which provided the funding for this work and the UI's Office of Undergraduate Research.

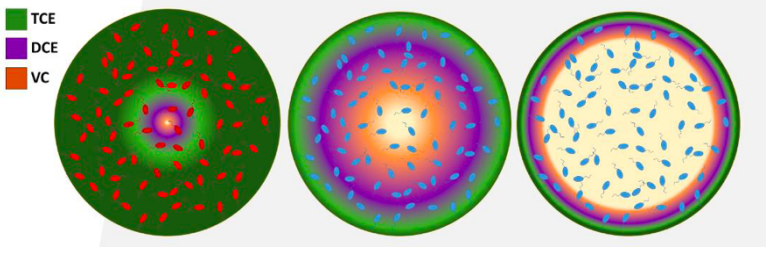
Fellowship Recipient: Alexis Dunham

Faculty Mentor: Kristopher Waynant, Dept. of Chemistry, COS

Project Title: Cryoprotectants for poly(vinyl alcohol) hydrogels

Abstract:
Bioremediation is an important process that treats pollutants using biological systems, and for this project, microorganisms. The microorganisms, a commercially purchased microbial consortia, are capable of metabolically eliminating the contaminates, specifically chlorinated aliphatic hydrocarbons (CAHs). The microbes, if added directly into these contamination sites will die due to the high concentrations, therefore a polymer hydrogel encapsulation process is utilized. Polyvinyl alcohol (PVA) hydrogels are known hydrogel polymeric systems for microbial encapsulation yet these systems are not optimized. Recent advances in our group have shown that a freeze/thaw gelation method is advantageous for optimal diffusion of CAHs in and byproducts out. The focus of this project is to add cryoprotectants to the gel formula to both keep the diffusion rates optimal and yet keep the microorganisms alive within the gels so they can do their job. A series of mixtures of PVA and cryoprotectants will be explored using trehalose, sucrose, dextran, glycine betaine, and glycerol as various cryoprotectants. The gels will be tested for both physical and chemical properties to make sure that their role plays little attention to the diffusion rates but helps sustain the cells to live. The desired outcome of this research is to find a cryoprotectant chemical that is compatible with PVA and will work well to keep the microorganisms that live within the gel alive.

Project Accomplishments:



- The 12% Betaine PVA hydrogel has the highest average diffusivity when compared to the other cryoprotectant hydrogels.
- 12% Betaine, 20% Glycerol, and 16% Sucrose PVA hydrogels have a higher average diffusivity than the regular 10% PVA hydrogel.
- The 14% Trehalose PVA hydrogel has the lowest standard error however, it has a lower average diffusivity than the rest of the hydrogel mixtures.
- Based on the average diffusivity of the 12% Betaine PVA hydrogel, the 12% Betaine would make for a good cryoprotectant as it keeps up the integrity of the hydrogel without sacrificing the movement of the liquids through the gel.

Future work: Further research will go into testing the compatibility of the cryoprotectant PVA hydrogel mixture with the microorganisms. They will be tested to see if they hold up as a cryoprotectant in bead form and if they are able to keep the microorganisms alive in colder environments.

Summary of Budget Expenditures:

Budget: Project Budget

Common Reagents to Gel formation	**Cost**
Poly(vinyl alcohol) (1 kg)	$ 110.00
Sodium alginate (500 g)	$ 115.00
Chitosan (250 g)	$ 231.00
$CaCl_2$	$ 35.00
Trehalose	$ 100.00

Glucose	$ 30.00
Glycine betaine	$ 65.00
Characterization (GelipHish, Powder XRD)	$ 150.00
General Lab supplies (gloves, glassware)	$ 89.00
Poster Printing	$ 75.00
Total	$ 1,000.00

Acknowledgement: This work was made possible by generous support from the Idaho State Board of Education which provided the funding for this work and the UI's Office of Undergraduate Research.

Fellowship Recipient: Hailey Faith

Faculty Mentor: Nathan R. Schiele, Dept. of Chemical and Biological Engineering, COE

Project Title: Exploring regulators of collagen crosslinking enzyme production by stem cells

Abstract:
Tendon is a type of collagenous connective tissue that attaches muscle to bone, allowing mechanical force transfer in the body. Tendons are characterized by their low healing capacity, and current tendinopathy treatments are ineffective, motivating the need for an effective tendon regeneration technique. Mesenchymal stem cells (MSCs) are multipotent stem cells known for their self-renewal and differentiation potential. Tissue regenerative methods using MSCs have been explored, suggesting a promising regenerative approach to tendon healing. There remains a limited understanding in how MSCs can be used to control tenogenic mechanical function during tendon healing. To further reduce this gap in knowledge, I aim to investigate how collagen crosslinking enzymes are regulated by MSCs. This research proposal aims to explore how transforming growth factor (TGF)β1 impacts collagen crosslinking enzyme lysyl oxidase (LOX) production in MSCs through the Akt signaling pathway. The objectives of this project are to 1) determine how MSCs treated with different concentrations of TGFβ1 impact LOX level production and 2) analyze how the Akt pathway regulates LOX production in MSCs. Results of this research will enhance the tendon tissue engineering field by determining how tendon mechanical function can be impacted while using MSCs as a tendon regenerative approach.

Project Accomplishments:

- TGFβ1 and TGFβ2 impact MSC morphology.
- TGFβ2 is a driver of LOX production.
- TGFβ1 was cytotoxic at high concentrations and did not upregulate LOX at low concentrations.
- Akt inhibition may decrease LOX production, but more work is needed to understand what role Akt is playing in LOX regulation.
- Findings improve understanding of the factors that impact tendon formation by MSCs.

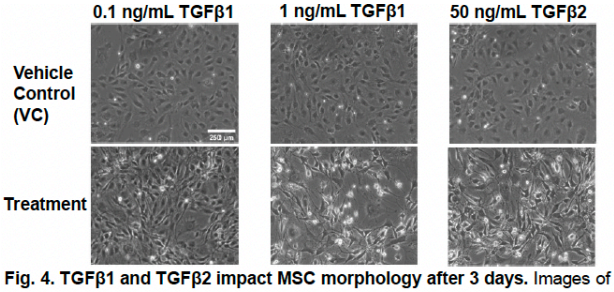


Fig. 4. TGFβ1 and TGFβ2 impact MSC morphology after 3 days. Images of MSCs treated with 0.1 ng/mL TGFβ1, 1 ng/mL TGFβ1, and 50 ng/mL TGFβ2 with their respective vehicle control.

Based on her work this summer as a SURF awardee, Hailey was the primary author of an abstract she submitted to the 2022 Biomedical Engineering Society (BMES) Annual Meeting in San Antonio, TX. BMES is one of the largest meetings of biomedical engineers and typically has an attendance of over 3,000. Her abstract was accepted, and she presented a research poster (citation below). Her poster was very well received, and several labs recommended that she apply to their programs for graduate school next year. Building on the research outcomes from over the summer, Hailey was also able to continue in my lab this fall semester to conduct additional experiments and work toward submitting a manuscript. Due to the opportunities that SURF provided, Hailey has a great start on her research career.

Faith HL, Schiele NR. Exploring TGFβs as regulators of collagen crosslinking enzymes for tendon tissue engineering. *Biomedical Engineering Society Annual Meeting*. October 12-15, 2022. San Antonio, TX. Poster Presentation. *The UI OUR supported her travel.*

Summary of Budget Expenditures:

Consumable Laboratory Supplies	
Rat MSCs (cat # scr027, Sigma) + shipping	*$730.00*
TGFβ1 (cat# 100-21, PeptroTech)	*$195.00*
SURF Required Costs	
Poster printing for UG Research Symposium	*$75.00*
	TOTAL $1,000.00

Acknowledgement: This work was made possible by generous support from the Idaho State Board of Education which provided the funding for this work and the UI's Office of Undergraduate Research.

Fellowship Recipient: Emily Hill

Faculty Mentor: Ann Brown, Dept. of Movement Sciences, CEHHS

Project Title: The Effect of a 4-week Tonal Strength Training Intervention on Body Composition, Muscular Strength& Emotional Well-Being Among Premenopausal Working Mothers

Abstract:
Premenopausal working women with children are often overlooked in the fitness world, dismissed as being too busy to prioritize strength training. However, the benefits of strength training on physical and emotional well-being can impact mothers and promote longitudinal health. The Tonal at home fitness program gives pre-menopausal women the opportunity to incorporate strength training without the stress and time of going to the gym and arranging childcare. Many physical changes occur following pregnancy and the needs of a child win over self-care. However, a premenopausal working mother population has not been studied in conjunction with strength training. This study aims to make not only fitness more accessible to premenopausal working mothers but encourage the incorporation of strength training into their workout routines. Over 4 weeks, working female mothers with at least 1 child older than 6 months and under the age of 18 will be recruited to participate in workouts 4 times a week of varying focuses and intensities. Physical and emotional measures will be taken before and after to assess the differences that the Tonal program can have. This pilot study can open future opportunities for this specific population to be studied with strength training and the Tonal equipment.

Project Accomplishments:
This study aimed to reframe the stigma around women strength training and to encourage and implement strength training into mother's routines. The stigma around hypertrophy has prevented women from considering ST and the Tonal system allows them to explore fitness in the comfort of their own home. The convenience eliminates the time consuming and nerve-wracking barriers that come with a gym membership. The system helps to train and educate users on proper form and routine. We are hoping to see an increase in enjoyment of working out and a positive increase in body perception and body composition. This study is one of the first studying this specific population and will open the doors for future expansion of strength training studies on women, specifically working mothers.

Summary of Budget Expenditures:

Dual-Energy X-Ray Absorptiometry (DEXA) Scans: in order to assess body composition DEXA scans will be conducted in the Human Performance Laboratory at the University of Idaho. Scan cost is $20/participant and contributes toward maintenance of the equipment. 15 participants x $18 x 2 scans = $540	$540
Participant Compensation: incentive to participate, compensation for travel to the HPL and time invested in the study. 15 participants x $25 = $375	$375
Poster Printing For presentation at the Undergraduate Research Symposium 2023	$75
Total Requested	$990

Acknowledgement: This work was made possible by generous support from the Idaho State Board of Education which provided the funding for this work and the UI's Office of Undergraduate Research.

Fellowship Recipient: Klara Isbell

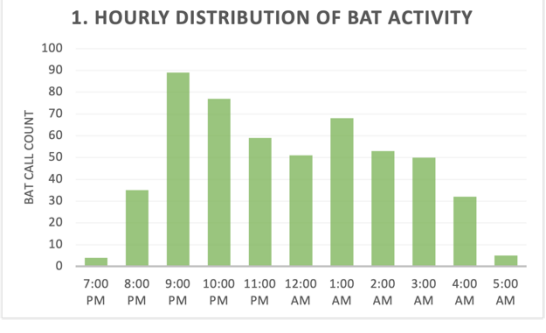
Faculty Mentor: Lisette Waits, Dept. of Fish and Wildlife Science, CNR

Project Title: Building a Species Inventory and Characterizing the Foraging Behavior of Bats in the UI Experimental Forest Using Acoustic Monitoring

Abstract:
There is a deficit of information about bats world-wide, and this holds true for bat populations in Idaho. As bats become increasingly exposed to diseases, human disturbance, and climate change, research to fill these knowledge gaps is essential for effective management and conservation. Bats use echolocation for navigation, foraging, and communication, which allows the use of acoustic monitors to noninvasively study bat populations. Using bioacoustic data collected in the University of Idaho (UI) Experimental Forest with Audiomouth monitors, my research would compare foraging patterns between seasons and characterize peaks in foraging activity observed in different species. Analysis of the bioacoustic data will also allow for the development of a species inventory for the UI Experimental Forest, providing information about bat community composition in this region of Idaho. This research will be part of my senior thesis project in the Ecology and Conservation Biology degree program.

Project Accomplishments:
According to the Kaleidoscope automatic identification, 11 species of bats were detected in the UI Experimental Forest. There are 14 species of bats native to Idaho.

- Most of the recordings require manual identification, and the automatically identified calls require verification by comparison with recordings from bat call libraries.
- There is more activity in the evening than morning. The peak activity time occurs between 9 -10 pm followed by a gradual decline with another peak between 3 – 4 am.
- The objectives of this study are to create a species inventory and to analyze for potential seasonal changes. Patterns relative to weather will also be assessed.



Klara Isbell had an abstract accepted and presented a poster presentation to the National Wildlife Society meeting in Spokane Nov 6-10, 2022. *The UI OUR supported her travel.*

Summary of Budget Expenditures:

Item	***Quantity***	***Unit Cost***	***Cost***
Gas	*10 weeks*	*$46.8 per week*	*$468*
AA batteries (packs of 24)	*14*	*$21*	*$294*
64GB MicroSD cards (packs of 3)	*7*	*$23*	*$161*
Poster printing	*1*	*$75*	*$75*
TOTAL			***$998***

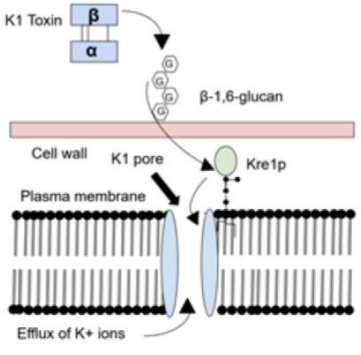
Acknowledgement: This work was made possible by generous support from the Idaho State Board of Education which provided the funding for this work and the UI's Office of Undergraduate Research.

Fellowship Recipient: Julia Major

Faculty Mentor: Paul Rowley, Dept. of Biological Sciences, COS

Project Title: The cell membrane protein Kre1 as a receptor for the K1 killer toxin in pathogenic yeasts

Abstract:
Killer yeasts are single-celled members of the Fungal kingdom that have the ability to create antifungal proteins called killer toxins. These killer toxins compete with other yeasts in their environment to inhibit growth and kill fungal cells. Due to these functions, killer yeasts are studied for their biomedical potential. Statistically speaking,1 in 3 women will get a yeast infection at one point in their lives. To treat vaginal yeast infections, azoles are the most commonly prescribed class of drugs, and are thought to be as much as 32% ineffective for treating these infections. *Candida glabrata* is a yeast responsible for vulvovaginal candidiasis and is highly susceptible to a killer toxin named K1, produced by baker's yeast (*Saccharomyces cerevisiae*). Kre1 is believed to be the secondary cell receptor for K1, potentially playing a role in yeast cell sensitivity. I hypothesize that Kre1 is the primary determinant of K1 sensitivity in diverse Ascomycota yeasts. This hypothesis is supported by findings from Breinig et al., among others, as their research found *kre1*Δ cells are completely resistant to K1, and expression of *KRE1* restored sensitivity. I will be further testing this hypothesis by extracting, cloning, and modifying *KRE1*s from a variety of *Candida* yeasts, expressing them in *kre1*Δ *S. cerevisiae*, and observing their levels of sensitivity to K1. I expect to find that successful expression of *KRE1* in *kre1*Δ *S. cerevisiae* cells will result in sensitivity to K1. Understanding the susceptibility determinants of pathogenic fungi will enable the potential future application of K1 as a novel therapeutic.



Project Accomplishments:

- 9 different primers were designed for PCR to amplify KRE1and collected the ORF of all KRE1 in the 9 yeast strains.
- gDNA was extracted from all 9 yeast strains prior to PCR and then PCR was run to amplify all KRE1 genes
- Began engineering a KRE1 knockout strain of *S. cerevisiae*
- After successful integration killer assays will be performed.
- The same protocol will be performed on the other 9 strains.

Summary of Budget Expenditures:

Item	Description	Cost
Pack of petri dishes (2)	Petri dishes for KT assays	$66.00
Pack of nitrile gloves (1)	Medium gloves for protection	$57.50
Rectangular assay plates 48/pack (1)	For killer toxin assays	$81.00
Topo TA cloning kit (1)		$449.00
Poster (1)		$75.00
Pipette Tips P20 tips 96/pack (3) P200 tips 96/pack (3) P1,000 tips 96pack (3)	Filtered micropipette tips	$110.00
		Total: $838.50

Acknowledgement: This work was made possible by generous support from the Idaho State Board of Education which provided the funding for this work and the UI's Office of Undergraduate Research.

Fellowship Recipient: Dawson Mathes

Faculty Mentor: Christopher Marx, Dept. of Biological Sciences, COS

Project Title: Phenotypic Heterogenity of PHB Production in Methylobacterium Extorquens

Abstract:
Lignin serves as an unexploited potential biofuel stock in order to produce butanol, due to the presence of methoxylated aromatics produced during the breaking down of lignin. Methoxylated aromatics have proven difficult to break down through microbial conversion due to their toxic nature. However, *Methylobacterium extorquens* has shown a promising ability to resist the toxicity from formaldehyde produced during the breaking down of such aromatics. The production of polyhydroxybutyrate (PHB) from methoxylated aromatics in *M. extorquens* is useful as a proxy for investigating potential 1-butanol production, as it follows the same carbon flow. This project aims to understand under which conditions *M. extorquens* yields the highest production of PHB while investigating the role of methoxylated aromatics as a carbon source. Diving further, this project goes past population level PHB quantification and aims to quantify single cell PHB production. Using a combination of flow cytometry and fluorescent microscopy this project will investigate the phenotypic heterogeneity of PHB production from methoxylated aromatics in *M. extorquens*.

Project Accomplishments:

- Growth of ancestral strains tend to lag behind evolved strains while the max growth rate remains equal
- Flow cytometry data suggests that there may be phenotypic heterogeneity in PHB production among cells of the same population

Dawson presented another poster at a recent UI College of Science Poster Session, Oct 28th, 2022.

Summary of Budget Expenditures:

Item	*Justification*	*Cost*
Poster	*Printing cost associated with poster for Undergraduate Research Symposium.*	*$75*
Flow Cytometry 3-Month Pass	*A 3-month pass is the mostcost-effective route for using flow cytometry opposed to$75/hr for normal use.*	*$500*
Lab Consumables (Described Below)	*General lab materials needed in order to complete the proposed research with M. extorquens.*	*$250*
Growth Media	*Media needed to culture M. extorquens.*	*$25*
PHB Extraction Chemicals	*Chemicals needed for PHB extraction of aim 1.*	*$50*
Nile red (100mg Sigma #72485)	*Staining used for single-cell PHB quantification.*	*$100*
Total:		*$1000*

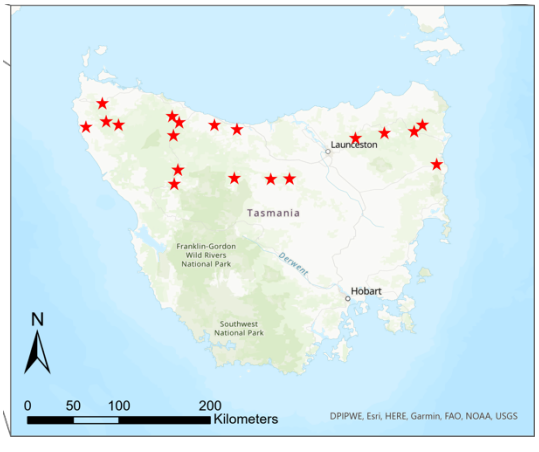
Acknowledgement: This work was made possible by generous support from the Idaho State Board of Education which provided the funding for this work and the UI's Office of Undergraduate Research.

Fellowship Recipient: Cooper Moon

Faculty Mentor: Laurel Lynch, Dept. of Soil and Water Systems, CALS

Project Title: Exploring the role of scavenger declines on soil microbial function

Abstract:
Top scavengers are essential to food web structure, and their declines have cascading effects on trophic levels below them. Tasmanian devils are critical scavengers endemic to the island of Tasmania. A highly transmissible and extremely lethal cancer (devil facial tumor disease; DFTD) is threatening devil populations across roughly 95% of their habitat. The east to west spread of this disease since 1996 provides a rare opportunity to test how the decline of top scavengers affects the rate of nutrient cycling from carcasses to soils and whether these dynamics shift microbial community composition and ecosystem function. Soil samples from five locations spanning the devil-density gradient will be tested to evaluate (1) how scavenger density impacts soil biogeochemistry and nutrient cycling; and (2) whether scavenger decline alters microbial community structure and function. Working alongside Drs. Lynch and Osburn I will extract DNA from the soil to characterize the diversity and functional potential of bacterial and fungal communities. Additionally, I will analyze the soil to quantify how biogeochemical properties change across the DFTD disease gradient. I will use various statistical analyses to determine the effect that scavengers have on ecosystem structure and function which is an important area of research that has not been widely explored.



Project Accomplishments:

- Measured pools of soil carbon, nitrogen, and phosphorus (solid- and dissolved-phase), pH, & moisture at 20 different sites from across Tasmania.
- Extracted bacterial and fungal DNA, quantified total microbial biomass
- Created linear mixed effects models and figures in R learning how to model along the way.

Cooper will be presenting his findings in December at a regional conference and will be second author on an upcoming manuscript. He will also be joining the project team on a 6-week trip to Tasmania.

Summary of Budget Expenditures:

DNeasy Power Soil Pro Kit	$500
SURF poster printing	$75

Acknowledgement: This work was made possible by generous support from the Idaho State Board of Education which provided the funding for this work and the UI's Office of Undergraduate Research.

Fellowship Recipient: Natasha Muparutsa

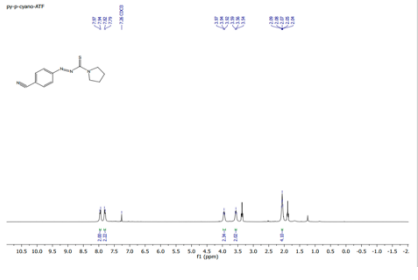
Faculty Mentor: Kristopher Waynant, Department of Chemistry, COS

Project Title: Synthesis of substituted ATF ligands and their evaluation for metal dissolution and recovery from Waste electronic and electrical equipment (WEEE)

Abstract:
The dissolution and recovery of metals from waste electronic and electric equipment is important because the demand of precious metals in industrialization has increased and the quantity of natural raw metals has decreased therefore increasing the costs. Extraction of these metals is also important because it helps with environmental legislation thus making it easier to dispose WEEE. This is considered the secondary source of metals. Precious metals are used in a wide range of electronic appliances like, phones, modems, and computers. The types of precious metals that are usually found in waste electronic and electric equipment are gold, copper, silver, and palladium. In this study, there will be the synthesis of substituted ATF ligands and evaluation for metal dissolution of waste electronic and electrical equipment. The process utilizes a mild redox-active ligand series (**a**zo**t**hio**f**ormamides or ATF) capable of dissolving metals and metal salts into ligand-metal coordinative complexes. These recovered complexes will undergo electrochemical processing to recover high purity metals and fresh ligand, providing a fully recyclable system. The recovery of metals from waste electronic and electric equipment has a positive impact on the environment because it reduces the toxic chemicals released by the WEEE into the atmosphere and reimagines how metals are sourced. The recovered metals can also be used for future industrial processes.

Project Accomplishments:

- Successfully synthesized, purified, and characterized multiple (4) ATF ligands and evaluated them with a series of copper(I) salts.
- Initiated experiments with waste electronic and electrical equipment and began to prep for Mass Spec analysis.
- Trained and accomplished on a variety of advanced software and instrumentation including NMR.



Summary of Budget Expenditures:

Material (supplier)	**Cost**
Poster (UI Printing)	$75
Phenyl hydrazine(s) (AK Scientific)	$150
Carbon disulfide (Thermo Fisher)	$35
N,N-Diethylamine (Acros)	$40
Methyl iodide (Chem Stores)	$45
Circuit boards (Amazon)	$85
NMR time (UI; $7.50/hr) x 10 h	$75
ICP-MS time ($75/sample)	$450
Consumables (gloves, syringes)	$45
Total	$1000

Acknowledgement: This work was made possible by generous support from the Idaho State Board of Education which provided the funding for this work and the UI's Office of Undergraduate Research.

Fellowship Recipient: Gabriel Nelson

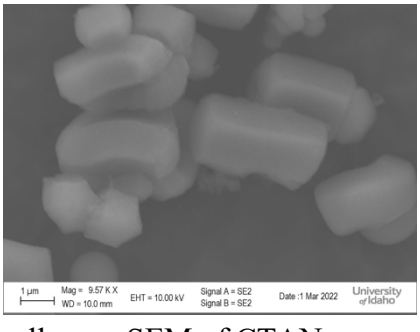
Faculty Mentor: Mark Roll, Materials Science Engineering Program, COE

Project Title: Ordered mesoporous silica synthesis by self-catalyzing surfactants

Abstract:
Mesoporous silica nanochannels are an important material with uses in fields such as drug delivery, thermal energy storage, and filtration. Synthesis of these structures requires a surfactant template, a silica precursor, and a reaction catalyst. A technique has been identified to ionically bind a nitrate catalyst to a cetyltrimethylammonium bromide surfactant template; effectively eliminating the need for additional catalysts when later synthesizing mesoporous silica. Preliminary data shows that mesoporous silica synthesized in this way produces promising results. This project will further explore key chemical relationships in the process of attaching the nitrate catalyst to surfactants. Additionally, it will provide a better understanding of the method of using these modified surfactants to synthesize organized mesoporous silica structures. This project will result in x-ray diffraction patterns confirming the crystal structure of synthesized silica particles and electron microscopy data verifying the microstructure of the synthesized silica. This project will allow for exploration of a new mesoporous silica synthesis technique. The results will be compared with silica synthesized by traditional means to see if this new process is an effective technique for producing mesoporous silica.

Project Accomplishments:

- Qualitative observations from synthesis indicate successful CTAN production
- CTAB and CTAN templates produce very similar ASNC
- Calcination decreases d-spacing and increases peak breadth
- Methanol degrades structure at RT and in Soxhlet extraction
- Current self-catalyzing procedure produces disordered structure. May be due to methanol wash step degrading structure



Future Work: Obtain Infrared spectroscopy of synthesized CTAN as well as an SEM of CTAN templated ASNC. Develop a methanol free synthesis of CTAN-templated silica and an ethanol based chemical surfactant removal and acquire ASNC synthesis with CTAC and F127 surfactant templates.

Summary of Budget Expenditures:

Item	Quantity	Price
Tetraethyl orthosilicate	500 mL	$35
Cetylammonium Bromide	100 g	$40
Nitrile Gloves	5 boxes at $40/box	$200
X-ray diffraction	12 hours at $10 per hour	$120
Scanning Electron Microscopy	5 hours at $65 per hour	$325
Focused Ion Beam/Scanning Electron Microscopy	1 hour at $200 per hour	$200
Poster printing		$75
TOTAL		**$995**

Acknowledgement: This work was made possible by generous support from the Idaho State Board of Education which provided the funding for this work and the UI's Office of Undergraduate Research.

Fellowship Recipient: Charis Peever

Faculty Mentor: Elizabeth Cassel, Department of Earth and Spatial Sciences, COS

Project Title: The Effects of Elevation and Evaporation on Soil Water Isotopic Composition Across the Cascades and Rocky Mountains

Abstract:
Stable isotope ratios of hydrogen and oxygen (δD and δ18O) in surface water are widely used as tracers of modern climate, water vapor sources, and atmospheric circulation. Geologic materials, such as clay minerals and volcanic glass, preserve ancient hydration waters in their structure, so their δD and δ18O values can be used to understand past climate and circulation. Modern meteoric water distributions are needed to interpret geologic records, but there are currently a limited number of precipitation stations across the northwestern U.S., and almost no soil water data, which is a better representation of the geologic record than the more common river water data. My project will use hydrogen and oxygen isotope ratios collected from soil water to create an isoscape (the distribution of δD and δ18O values across a region). This isoscape will be used 1) as a modern baseline for active paleo-studies, 2) to compare to the existing river water data to identify where river water data varies from soil water, and 3) most importantly, to identify areas with high evaporation rates, which are likely experiencing variations due to climate change.

Project Accomplishments:
My project had me digging a soil pit near each of the locations where volcanic glass is sampled for the paleo-elevation data for the most accurate comparison. At each soil pit, I took a sample every 20 cm, up to 1 m depth, sealing the sample immediately to limit any evaporation due to air exposure. Sampling at multiple depths within the soil column will help in identification of evaporation trends (Breecker et al., 2009). Soil Water Extraction: For preparing the samples, I will be using the cryogenic vacuum extraction line in Dr. Cassel's lab to extract all water from the soil sample, following the methods of Orlowski et al. (2018). Isotope ratio analysis of the extracted waters will be done at the University of Texas – Austin, where the samples will be analyzed for both δD and δ18O values.

Summary of Budget Expenditures:

Budget Item	Cost	Justification
Travel	$250	Rental vehicle and fuel to travel to each sampling site.
Lodging	$75	Campground fees
Per Diem	$150	Per Diem is budgeted at ($50/trip x 3 trips)
Analysis for Deuterium	$250	25 samples for deuterium isotope analysis @ cost of $10 per sample.
Analysis for Oxygen	$200	25 samples for Oxygen isotope analysis @ cost of $8 per sample
Poster	$75	ICUR Undergraduate Research Symposium.
Total Cost:	$1,000	

Acknowledgement: This work was made possible by generous support from the Idaho State Board of Education which provided the funding for this work and the UI's Office of Undergraduate Research.

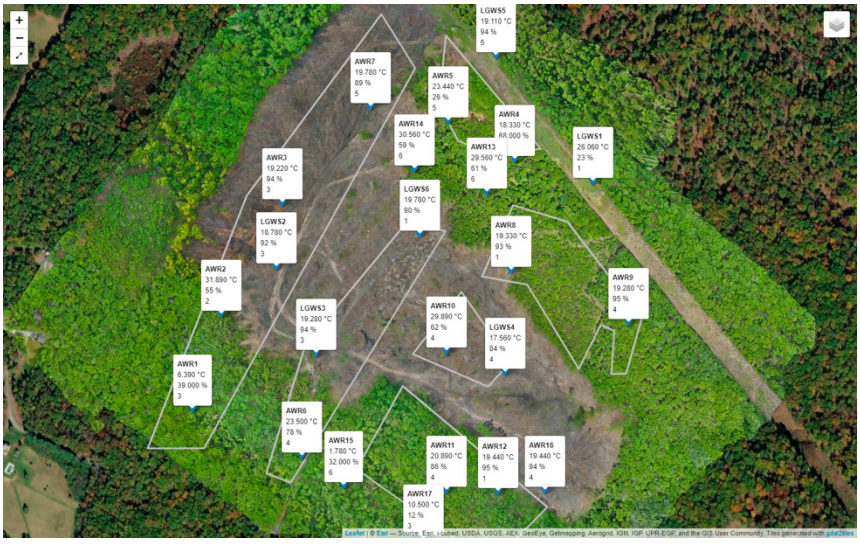
Fellowship Recipient: Zach Preston

Faculty Mentor: John Shovic, Department of Computer Science, COE

Project Title: Project VineHeart

Abstract:
To improve the efficiency of their vineyard, Laurel Grove Wine Farm is introducing a system of sensors that will read information about various elements of the vineyard and create aggregate data, to help the owners make decisions about the ways they use resources and tend to the vineyard. This "smart vineyard" system will improve the agricultural practices used in the vineyard and make its operation more environmentally friendly. The smart vineyard system will increase efficiency for Laurel Grove Wine Farm and enhance the care for the vineyard. Additionally, the plan is to create a modular and scalable system that can be applied to a variety of agricultural scenarios. Sensors could be added or removed to fit the needs of a wide variety of environments. The smart vineyard system will include a dashboard that will make it easy for Laurel Grove Wine Farm to review the data that's collected, which will be the primary focus of my contribution to the project.

Project Accomplishments:
The Project VineHeart dashboard is a robust interface for analyzing the vineyard at Laurel Grove Wine Farm. The options that it provides give a multitude of ways to interpret the conditions of the vines and their environment. The benefit of the dashboard is more-informed decisions when taking care of the vines, and maintaining the land and air where they grow. This dashboard is just one step in the sequence for the utilities and services provided by Project VineHeart.



Summary of Budget Expenditures:
Poster $75
Laptop Capable of running Unity for Dashboard $875
Total $950

Acknowledgement: This work was made possible by generous support from the Idaho State Board of Education which provided the funding for this work and the UI's Office of Undergraduate Research.

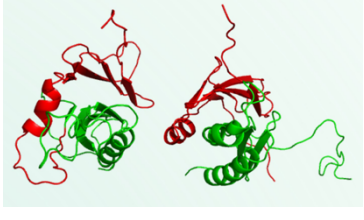
Fellowship Recipient: David Reetz

Faculty Mentor: Paul Rowley, Dept. of Biological Sciences, COS

Project Title: Elucidating the 3D structures of *Saccharomyces* killer toxins using the cutting-edge protein prediction algorithm AlphaFold2

Abstract:
Fungi cause millions of deaths every year and are responsible for a significant portion of food spoilage around the world. There is a great need to find new, more effective methods to combat harmful fungi. Killer yeasts, which produce antifungal 'killer' toxins, are a potential solution to this problem. This research is aimed at gaining structural understanding of known killer toxins from *Saccharomyces* yeasts to better understand their mechanism of action against pathogenic fungal species. I have already generated preliminary structural models of eleven *Saccharomyces* toxins using the neural network AlphaFold2. This has provided the first glimpse of the tertiary structure of proteins that have resisted attempts to determine their structure empirically for decades. To build more confidence in these *in silico* models, each will be energetically optimize using the molecular dynamics software GROMACS. The most confident model will undergo *in silico* mutagenesis using FoldX. Finally, the accuracy of the simulated mutations will be validated by testing their effect on toxin function against pathogenic yeasts using wet lab techniques from molecular and cell biology. This multidisciplinary approach will put researchers at the University of Idaho at the leading edge of antifungal protein research with the aim to develop new classes of therapeutics.

Project Accomplishments:



K1 is a killer toxin with 3 distinct domains. By using AlphaFold2 modeling software, we were able to build homologs of K1. These homologs indicated that the interaction between the alpha and gamma domains of the K1, K1L, and KKT proteins. Now exploring yeast 2 hybrid assays to test the interaction between the alpha and gamma domains of K1 and autoimmunity assays. David Reetz recently presented a poster at the American Society of Microbiology (ASM) and won a best poster prize.

Summary of Budget Expenditures:

Materials	Price/qt	Quantity	Total
Nitrile Gloves	$ 140.00	1	$ 140.00
Primer Synthesis	$ 5.00	14	$ 70.00
Phusion Master Mix	$ 650.00	0.1	$ 65.00
HyPure Water	$ 12.00	1	$ 12.00
T4 DNA ligase	$ 64.00	1	$ 64.00
Competent E. coli	$ 233.00	1	$ 233.00
S. Cerevisiae BY4741	$ 90.00	1	$ 90.00
Fisher Bioreagents Agar	$ 230.00	0.4	$ 92.00
Yeast Extract	$ 58.00	0.25	$ 14.50
Peptone	$ 189.00	0.24	$ 47.10
Dextrose	$ 130.00	0.25	$ 32.50
Methylene Blue	$ 48.00	0.05	$ 2.40
Galactose	$ 25.00	1	$ 25.00
Petri dishes 100mm x 15mm	$ 75.00	0.5	$ 37.50
Poster Printing			$ 75.00
Total		$ 1,000.00	

Acknowledgement: This work was made possible by generous support from the Idaho State Board of Education which provided the funding for this work and the UI's Office of Undergraduate Research.

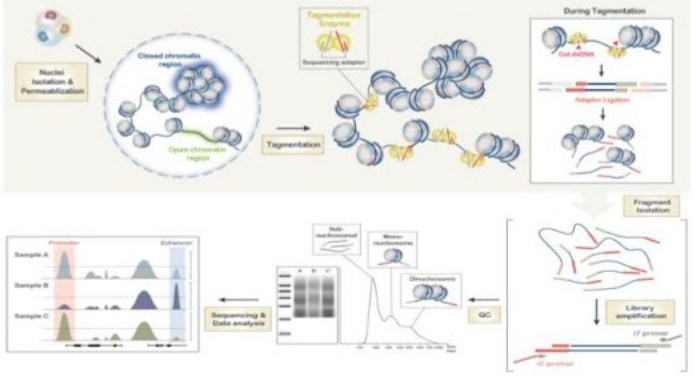
Fellowship Recipient: Julia Woods

Faculty Mentor: Brenda Murdoch, Dept. of Animal, Veterinary and Food Sciences, CALS

Project Title: Transcription levels in open chromatin regions and RNA expression in Angus cattle

Abstract:
The sustainability of the livestock industry hinges upon the improvement of production efficiency to the benefit of both consumers and producers. A large contribution to this betterment has been achieved through innovation in genetics, including the rapidly expanding field of epigenetics. Our goal for this research is to improve our understanding of the relationship of open chromatin regions and RNA expression in Black Angus cattle. Knowing what chromatin is open and where RNA is transcribed helps indicate the presence of other factors that may affect transcription. Their interactions will be analyzed using ATAC-seq and RNA-seq of four tissue types from four animals as biological replicates. Having a multitude of sample types from different specimens allows for better comparison to draw broader conclusions about open chromatin regions and RNA expression. Not only will the results from this project contribute to the completion of the overall bovine epigenome project, but they will also provide information to researchers that can in turn aid in the application of genomic tools and data toward production strategies.

Project Accomplishments:
Through characterizing the transposase-accessible and actively transcribed regions of the genome of 4 biological replicates and 3 tissue types, we expect to define tissue-specific signals as well as capture biological variation. The results of this study will contribute to the current understanding of chromatin accessibility profiles in economically important livestock breeds. It was discovered that proximity of regulatory enhancers decreases in tissue-specific open chromatin regions, indicating a long-range modulation of transcription. Ongoing work will provide significant verification of the epigenome in relevant species of livestock genetics.



Summary of Budget Expenditures:

Item (Size, Amount)	*Supplier*	*Cost Per Item ($)*	*Number of Items*	*Total Cost*
RNA Extraction Kits	*Qiagen*	*$558.00*	*1 (50 spincolumns)*	*$558.00*
Misc. Lab supplies	*Thermo Fisher*	*Various*	*Various*	*$217.00*
Shipping samples	*FedEx Approx.*	*$100*	*2 Shipments*	*$150.00*
Research Poster	*U of I Printing Center*	*$75*	*1*	*$75.00*
Total Cost:				*$1,000*

Acknowledgement: This work was made possible by generous support from the Idaho State Board of Education which provided the funding for this work and the UI's Office of Undergraduate Research.

Fellowship Recipient: Elizabeth Worley

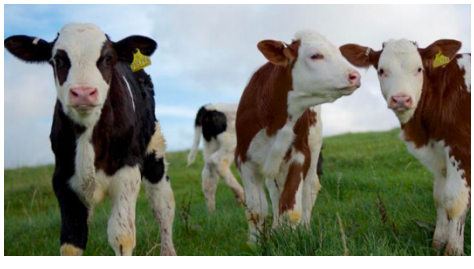
Faculty Mentor: Gwinyai Chibisa, Animal Veterinary and Food Science, CALS

Project Title: Determining stress response of dairy calves when transported at different ages

Abstract:
In past research studies from the U.S., it has been shown that the age at which a dairy calf is transported could impact their long-term health. Transport-related stress can contribute to a higher susceptibility of digestive and respiratory disease and can reduce production performance into adulthood. However, past studies have relied solely on the measurement of blood cortisol, a stress hormone, to determine the effects of transportation. This can be an issue since cortisol does not fully characterize the impact of transport-related stress, especially in young calves as the cortisol response is still muted. Therefore, this study will not only focus on cortisol, but will also evaluate other measures like white and red blood cell counts, body weight, and heart and respiration rates. This will hopefully provide a better picture of how calves at different ages respond to transportation.

By determining the ideal age to transport calves, dairy farms can ensure the welfare of each calf in the facility. Therefore, we can develop better management strategies to not only improve animal welfare, but to help reduce deaths and the use of antibiotics to treat sickness caused by transported-related stress. This will help increase productivity and efficiency in the dairy industry, while increasing profitably and the overall success of a dairy operation.

Project Accomplishments:
With this study, we will create new evidence-based recommendations for the ideal age to transport calves. Therefore, we can increase the sustainability of dairy operations, as well as increase the production efficiency of dairy cows in the future. Calves were transported over 8 hours. Body weights were measured both before and after transport. Blood work was done following transport.



Summary of Budget Expenditure:

Budget: *Item*	***Amount***
1. Blood Analysis	$600
2. Lab Supplies	$325
3. Poster Printing	$75
Total	***$1000***

Acknowledgement: This work was made possible by generous support from the Idaho State Board of Education which provided the funding for this work and the UI's Office of Undergraduate Research.

Students, Project Titles, and Abstracts of UI Gen Ed SURF recipients not presenting at ICUR

Fellowship Recipient: Madison Wolf
Faculty Mentor: Omi Hodwitz, Dept. of Culture, Society and Justice, CLASS
Project Title: Missing and Murdered Indigenous Women, Girls, and Two-Spirit (MMIWG2) database
Abstract:

In North America, Indigenous women, girls, and Two-Spirit (IWG2) are at an increased risk of victimization. The matter long predates the present-day movement for a resolution. As a result, there is a severe data deficit regarding Missing and Murdered Indigenous Women, Girls, and Two-Spirit (MMIWG2) in both the United States (U.S.) and Canada. On top of existing struggles within Indigenous communities, there is fear that they or a loved one will go missing at any moment and receive little to no aid in their recovery. Without adequate information, legislators cannot address the situation at hand. The MMIWG2 database provides this necessary information.

The MMIWG2 research consists of two phases. The first phase will involve gathering cases of MMIWG2 in the U.S. and Canada. The second phase will consist of verifying the authenticity of each missing person's case and collecting corresponding information. The corresponding information will include, among other things, the time between an individual being reported missing and law enforcement responses, and if the case received follow-up or resolution. This will provide the verified information needed to assess and understand MMIWG2 and the effectiveness of each country's response to the issue.

Fellowship Recipient: John Mansanarez
Faculty Mentor: Christine Berven, Dept. of Physics, COS
Project Title: Experimental Tests of Type-II Three-Dimensional Levitation and Energy Loss Quantization
Abstract:

This project will be a continuation of testing dynamic force models for Type-II Superconductor Permanent Magnet (SCPM) bearings. Experiments will continue to test horizontal restoring forces of the SCPM bearings. Further expanding trust into our three dimensional predictive model. We intended to use a variety of Halbach arrays and compare to predictive theory that requires no fitting parameters, while other popular models[EJ] require data fitting and bearing prototyping. The second objective is to gain a stronger understanding of the energy loss within our systems. There are currently a few flux flow and creep models are used to explain energy loss in superconductivity, but these require current measurements that can only be obtained through experimentation. Our goal is to construct a solid predictive theory that would not rely on experimental fitting. As well as design experimental procedures to rigorously test our hypothesis. The major goals to achieve by the end of the summer would be to finish the two sets of experiments mentioned before and follow up with finalizing two papers that would be submitted for publication.

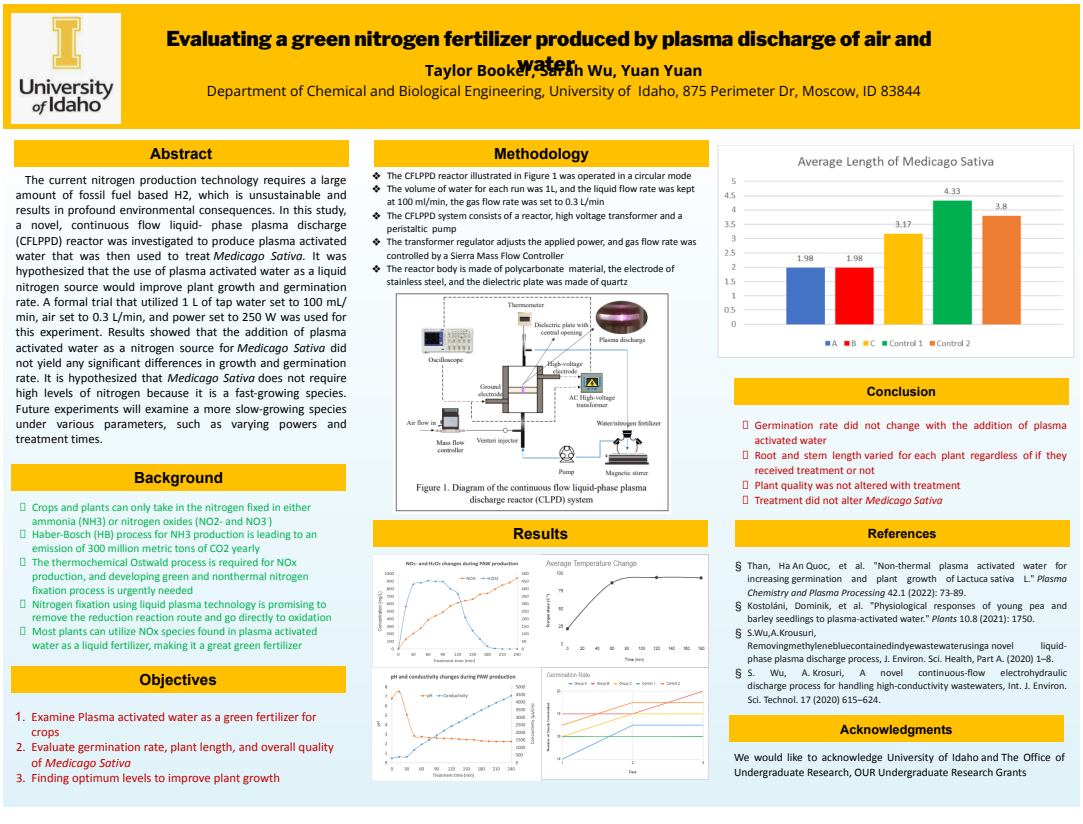
Acknowledgement: Acknowledgement: This work was made possible by generous support from UI's Office of Undergraduate Research.

These Faculty members have been given a warning and will need to mention this warning in their letters of recommendation for future applicants of SURF funding.

Name, Mentor's Name and Titles of Fall 2022 Projects

Student Name	Faculty Mentor	Department	College	Project Title
Brazil-Geyshick, Asiah	Chelsey Byrd Lewallen	Family and Consumer Sciences	CALS	Kombucha Leather Research Project
Goebel, Peter	Eva Strand	Ecology and Conservation Biology	CNR	Sampling, Identifying, and Charring Experiments of Woody Taxa to Understand Past Palaeoecological Conditions and Early Human-Wood Relationships in the Great Basin
Hill, Katherine	Paul Rowley	Biological Sciences	CoS	An investigation into the role of the Kre1 membrane receptor in killer toxin immunity
LaVoie, Nathan	Paul Rowley	Biological Sciences	CoS	Site-Directed Mutagenesis of Conserved Cysteines found in an Aerolysin-like toxin
Major, Julia	Paul Rowley	Biological Sciences	CoS	The cell membrane protein Kre1 as a receptor for the K1 killer toxin in pathogenic yeasts
Reetz, David	Paul Rowley	Biological Sciences	CoS	Elucidating the 3D structures of Saccharomyces killer toxins using the cutting-edge protein prediction algorithm AlphaFold2

Appendix of Posters:



Evaluating a green nitrogen fertilizer produced by plasma discharge of air and water.

Taylor Booker, Sarah Wu, Yuan Yuan

Department of Chemical and Biological Engineering, University of Idaho, 875 Perimeter Dr, Moscow, ID 83844

Abstract

The current nitrogen production technology requires a large amount of fossil fuel based H2, which is unsustainable and results in profound environmental consequences. In this study, a novel, continuous flow liquid- phase plasma discharge (CFLPPD) reactor was investigated to produce plasma activated water that was then used to treat *Medicago Sativa*. It was hypothesized that the use of plasma activated water as a liquid nitrogen source would improve plant growth and germination rate. A formal trial that utilized 1 L of tap water set to 100 mL/ min, air set to 0.3 L/min, and power set to 250 W was used for this experiment. Results showed that the addition of plasma activated water as a nitrogen source for *Medicago Sativa* did not yield any significant differences in growth and germination rate. It is hypothesized that *Medicago Sativa* does not require high levels of nitrogen because it is a fast-growing species. Future experiments will examine a more slow-growing species under various parameters, such as varying powers and treatment times.

Background

- Crops and plants can only take in the nitrogen fixed in either ammonia (NH3) or nitrogen oxides (NO2- and NO3-)
- Haber-Bosch (HB) process for NH3 production is leading to an emission of 300 million metric tons of CO2 yearly
- The thermochemical Ostwald process is required for NOx production, and developing green and nonthermal nitrogen fixation process is urgently needed
- Nitrogen fixation using liquid plasma technology is promising to remove the reduction reaction route and go directly to oxidation
- Most plants can utilize NOx species found in plasma activated water as a liquid fertilizer, making it a great green fertilizer

Objectives

1. Examine Plasma activated water as a green fertilizer for crops
2. Evaluate germination rate, plant length, and overall quality of *Medicago Sativa*
3. Finding optimum levels to improve plant growth

Methodology

- The CFLPPD reactor illustrated in Figure 1 was operated in a circular mode
- The volume of water for each run was 1L, and the liquid flow rate was kept at 100 ml/min, the gas flow rate was set to 0.3 L/min
- The CFLPPD system consists of a reactor, high voltage transformer and a peristaltic pump
- The transformer regulator adjusts the applied power, and gas flow rate was controlled by a Sierra Mass Flow Controller
- The reactor body is made of polycarbonate material, the electrode of stainless steel, and the dielectric plate was made of quartz

Figure 1. Diagram of the continuous flow liquid-phase plasma discharge reactor (CLPD) system

Results

Conclusion

- Germination rate did not change with the addition of plasma activated water
- Root and stem length varied for each plant regardless of if they received treatment or not
- Plant quality was not altered with treatment
- Treatment did not alter *Medicago Sativa*

References

§ Than, Ha An Quoc, et al. "Non-thermal plasma activated water for increasing germination and plant growth of Lactuca sativa L." *Plasma Chemistry and Plasma Processing* 42.1 (2022): 73-89.
§ Kostolàni, Dominik, et al. "Physiological responses of young pea and barley seedlings to plasma-activated water." *Plants* 10.8 (2021): 1750.
§ S.Wu,A.Krousuri, Removingmethylenebluecontainedindyewastewaterusinga novel liquid-phase plasma discharge process, J. Environ. Sci. Health, Part A. (2020) 1–8.
§ S. Wu, A. Krosuri, A novel continuous-flow electrohydraulic discharge process for handling high-conductivity wastewaters, Int. J. Environ. Sci. Technol. 17 (2020) 615–624.

Acknowledgments

We would like to acknowledge University of Idaho and The Office of Undergraduate Research, OUR Undergraduate Research Grants

Trends of Missing and Murdered Indigenous Women, Girls and Two Spirit

Christina Briggs-Mathers (brig7281@vandals.uidaho.edu)
Dr. Omi Hodwitz (omi@uidaho.edu)
Department Of Culture, Society, and Justice
University of Idaho
Department of Culture, Society and Justice

Research Goals

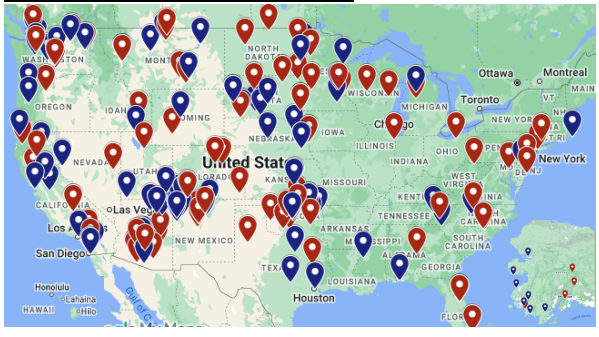
There are numerous databases that record and report MMIWG2 in the United States. However, these are scattered over various sources and, as such, tend to be piecemeal at best, limiting our ability to understand this phenomenon. To address this issue, we are building a central database that brings these cases together so that the extent and nature of MMIWG2 can be better understood.

Methods

Indigenous people are at higher risk of becoming victims of violence than any other racial or ethnic group in the United States. As such, the need to empirically assess this phenomenon is pressing. In order to do so, we have identified approximately 1000 cases of MMIWG2 in the United States between 1980 and 2020, of which 30% (and counting) have been verified and coded. Our primary sources include community databases, media articles, government reports, and government databases.

Murdered and Missing Locations in USA

Murdered Missing



Current Victim Demographics

Men Murdered Women	55
Men Murdered Men	7
Men Murdered Young Girls	8
Women Murdered Men	1
Women Murdered Women	6
Women Murdered Young Girls	3
Indigenous Perpetrator	14
Non-indigenous Perpetrator	1

Current Solve Rate

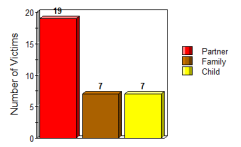
Police have arrested and charged someone in 67 cases out of 318. Which leaves a solved case rate of 21%

Known Perpetrator Demographics

Sex	Age	Amount
Female	Under 18	38
Male	Under 18	12
Unknown	Under 18	7
Female	Adult	113
Male	Adult	83
Unknown	Adult	0
Female	Unknown	12
Male	Unknown	6
Unknown	Unknown	47

Sample Size: 318

Known Domestic Violence Murders



Summary

Our growing set of coded cases suggests a few key trends. First, most of the cases originate on the west side of the country, illustrating the importance of location. Second, the police do not have a high closure rate and the cases that they do solve usually involve a perpetrator that is already known to the victim. Third, the victims are more likely to be female-presenting, while the perpetrators are more likely to be male-presenting.

Funding

This research was funded by the University of Idaho's Office of Undergraduate Research.

References

King, S., & Hodwitz, O. (2020). What's the plan? Broadening the MMIWG2 conversation in North America. Comparative American Studies an International Journal. https://doi.org/10.1080/14775700.2021.1877082

Development of Effective Marketing Strategies based on Potential Consumer Perspectives of Junior Livestock Shows and Sales

Melinda Cross
Latah Market Animal Sale, University of Idaho
University of Idaho

Background

The number of buyers and supporters participating in Junior Livestock Shows has been decreasing across the country, especially after the COVID-19 pandemic. From financial responsibility to character development--Junior Livestock Shows help children build important life skills. There have been numerous studies done about the incentivss behind junior livestock shows for youth. There are social skills leared, respobsibility, attention to deatil, time management, and the possibillity of being connected with future employers. There is then the largest incentive: the financial potential.What is necessary for students to succeed is for there to be community support and involvement as buyers. While there is information on buyer concerns, there is little information published describing livestock buyer profiles. To completely understand the consumers and their motivations, research is needed to compile demographics and measure attendance.

Methods

- Interviews were done with top buyers to gain an understanding of what buyers need, and what can be done to better accomodate them. They were given a mug with the LMAS logo and portable battery chargers as a thank you.
- A booth was set up at the Moscow Farmer's Market where 4-H/FFA members were educating people about the sale, and their projects. There were posters hung up with information about pricing for buying animals on the hoof at a sale like LMAS versus in the store. There was also a poster about freezer space, and how much you need for each animal. Lastly, there was a raffle to try to get people interested in signing up to recieve more information about the sale.
- A social media page was started, and updated weekly. Educational posts were done often to show people why buying from the sale is beneficial for their wallet. 4-H and FFA members taking their animals through the sale were also given the opportunity to be featured.
- Local Latah county fair board and livestock leader's meetings were attended to gain an inside view on what is happening with the sale, and to relay the data from past buyers to those running the meetings.

Data Collected

From interviews and research done alll current and past buyers the suggested:

- A later sale time
- Thank you cards from kids with pictures
- More contact from kids talking about their own projects
- More appreciation for the buyers from the sale, and an easier way to sign up to be a buyer.

We also discovered there was simply a lack of knowledge in the county about what the sale and 4-H/FFA even were. This contributed to the lack of community support.

Future Plans

We took all the words from the past buyers as well as from the community. We moved the sale to a later time and are offering a buyer's luncheon. We also have ways for buyers to sign up ahead of time to make it more time efficient. We are proud of the outreach and education we were able to provide in the hopes that we can improve the Latah Market Animal Sale.

Cryoprotectants for PVA Hydrogels

Alexis Dunham[1,2], Carson Silsby[2], Dr. Kristopher Waynant[1], Dr. James Moberly[2], and Dr. Mark Roll[2]
Department of Chemistry[1], Department of Chemical and Biological Engineering[2]; University of Idaho

Objective

The purpose of this research is to optimize the PVA hydrogel solution with a cryoprotectant so microorganisms encapsulated in the hydrogel can survive freeze/thaw cycling. Glycerol, betaine, sucrose, and trehalose were tested as cryoprotectants in a PVA gel mixture to determine which is best by comparing the diffusivities of the cryoprotected gel mixture to the original PVA hydrogel.

Introduction

- A Bioremediation process utilizing polymer encapsulated hydrogels allows for an efficient reduction of already existing CAH pollutants such as TCE and VC.
- TCE and VC are among the 15 commonly found CAH pollutants at all superfund sites.
- Microorganisms encapsulated in a PVA hydrogel proves to be an effective way to keep the microorganisms alive in contamination sites.

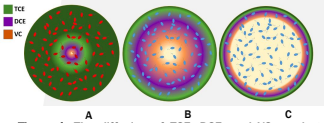


Figure 1. The diffusion of TCE, DCE, and VC needs to be controlled so the microorganisms are able to complete a four-step reaction, in the case of TCE, that degrades the CAH to benign product. A) CAH diffuses too quickly and so the microorganisms become too overwhelmed and die. B) The CAH diffuses at the correct rate so remediation can be successful. C) The CAH is diffusing too slow so the microorganisms in the middle starve and die.

- Cryoprotecting the gels will allow for the incorporation of needed cell densities to optimize bioremediation.
- Glycerol, Sucrose, Betaine, and Trehalose are used in a PVA solution to serve as a cryoprotectant for the gels.

Acknowledgements

This research was funded in part by Summer Undergraduate Research Fellowships from the Office of Undergraduate Research at the University of Idaho

This research was funded in part by the National Science Foundation. Award Number: 1805358

PVA Hydrogel Preparation

1. Combine PVA with water to create the initial gel mixture.
2. Place the gel mixture with a stir rod in a hot water bath and allow the gel to mix and heat for at least an hour.
3. Pour the gel mixture into the gel mold and place in the freezer for at least 24 hours.
4. Begin the five freeze-thaw cycles. Conclude the cycles by putting the gels in a beaker of water to equilibrate for at least 24 hours.
5. Put the gels in the GellipHish apparatus for at least 24 hours to allow for data collection.

Cryoprotectant Results

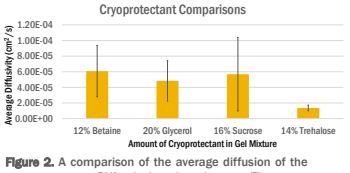


Figure 2. A comparison of the average diffusion of the cryoprotectant PVA hydrogel mixture. They are compared using the average diffusivity.

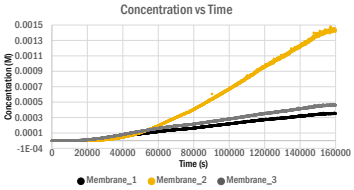


Figure 3. The diffusion of hydrogen ions over time for a 20% glycerol 10% PVA hydrogel mixture.

Results and Discussion

- The 12% Betaine PVA gel has the highest average diffusivity when compared to the other cryoprotectant gels.
- 12% Betaine, 20% Glycerol, and 16% Sucrose PVA gels have a higher average diffusivity than the regular 10% PVA gel.
- The 14% Trehalose PVA gel has the lowest standard error however, it has a lower average diffusivity than the rest of the gel mixtures.
- Based on the average diffusivity of the 12% Betaine PVA gel, the 12% Betaine would make for a good cryoprotectant as it keeps up the integrity of the gel without sacrificing the movement of the liquids through the gel.

Future Work

Further research will go into testing the compatibility of the cryoprotectant PVA gel mixture with the microorganisms. They will be tested to see if they hold up as a cryoprotectant in bead form and if they are able to keep the microorganisms alive in colder environments.

University of Idaho Office of Undergraduate Research

Exploring regulators of collagen crosslinking enzymes for tendon tissue engineering

University of Idaho Department of Chemical and Biological Engineering

Hailey L. Faith, and Nathan R. Schiele
Department of Chemical & Biological Engineering, University of Idaho, Moscow, ID

University of Idaho Office of Undergraduate Research

Background

- Tendon is a collagenous tissue that attaches muscle to bone, allowing mechanical force transfer and movement.
- Tendon injuries are common, heal poorly, and current treatments are ineffective.
- Transforming growth factor **(TGF)β1** is a growth factor known to play a role in tendon injury and healing, while **TGFβ2** promotes differentiation toward the tendon lineage in mesenchymal stem cells **(MSCs)**.
- MSCs are multipotent stem cells known for their self-renewal and differentiation potential.
- MSCs have been explored as a regenerative therapy for tendon injury, but how MSCs are regulated to form mechanically functional tendon is unknown.
- Lysyl oxidase **(LOX)** is a collagen crosslinking enzyme that is crucial in forming a mechanically functional tendon, but how LOX production is regulated in MSCs remains unexplored.
- **Akt** cell signaling pathway may be activated by TGFβs and plays a role in tenogenesis, but impacts on LOX are unknown.
- **MK-2206** is an inhibitor of Akt signaling.

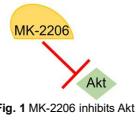


Fig. 1 MK-2206 inhibits Akt

Hypothesis & Objectives

Hypothesis: *TGFβ1 and TGFβ2 increase LOX production through activation of Akt signaling in MSCs.*

Objectives:
1) Determine how MSCs treated with TGFβ1 and TGFβ2 impact LOX production levels and Akt activation.
2) Analyze how Akt signaling regulates LOX production in MSCs.

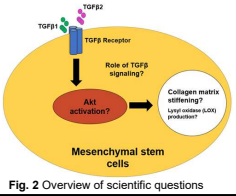


Fig. 2 Overview of scientific questions

Methodology

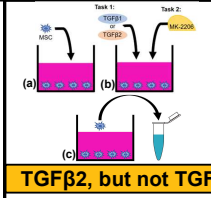


Fig. 3 MSCs were **(a)** seeded at 10,000 cells/cm² then **(b)** cultured with different TGFβ1 concentrations (0.1 ng/mL, 1 ng/mL, 2 ng/mL, 10 ng/mL) or 50 ng/mL of TGFβ2 for **task 1**. MSCs were cultured and treated with 0.1 ng/mL TGFβ1 and 500 nM MK 2206 or 50 ng/mL of TGFβ2 with 500 nM MK 2206 for **task 2**. After 1, 3, and 7 days, MSC morphology was examined and MSCs were **(c)** collected for protein quantification using western blotting techniques.

TGFβ2, but not TGFβ1, increases LOX levels

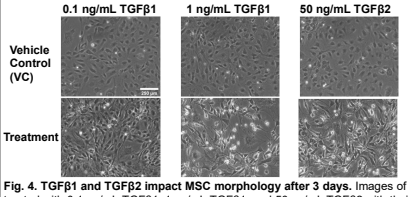


Fig. 4. TGFβ1 and TGFβ2 impact MSC morphology after 3 days. Images of MSCs treated with 0.1 ng/mL TGFβ1, 1 ng/mL TGFβ1, and 50 ng/mL TGFβ2 with their respective vehicle control.

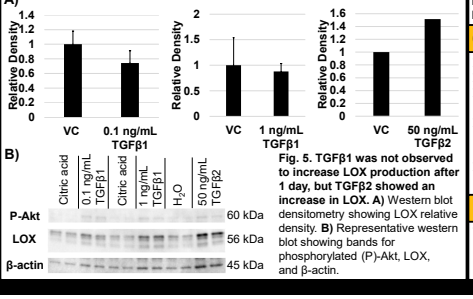


Fig. 5. TGFβ1 was not observed to increase LOX production after 1 day, but TGFβ2 showed an increase in LOX. A) Western blot densitometry showing LOX relative density. **B)** Representative western blot showing bands for phosphorylated (P)-Akt, LOX, and β-actin.

Akt inhibition reduces TGFβ2-enhanced LOX production

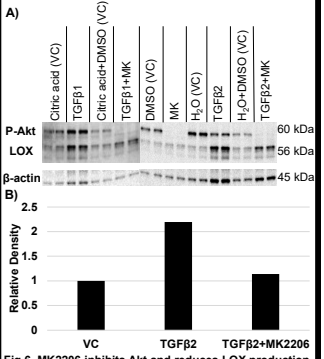


Fig.6. MK2206 inhibits Akt and reduces LOX production with TGFβ2 treatment after 1 day. A) Representative western blot showing bands for phosphorylated (P)-Akt, LOX, and β-actin. **B)** Western blot densitometry showing LOX relative density.

Conclusion & Future Directions

- TGFβ1 and TGFβ2 impact MSC morphology.
- TGFβ2 is a driver of LOX production.
- TGFβ1 was cytotoxic at high concentrations and did not upregulate LOX at low concentrations.
- Akt inhibition may decrease LOX production, but more work is needed to understand what role Akt is playing in LOX regulation.
- Findings improve understanding of the factors that impact tendon formation by MSCs.

Acknowledgements

This project was made possible by the University of Idaho Office of Undergraduate Research, Summer Undergraduate Research Fellowship (to HLF), the National Science Foundation # 2145004 (to NRS), and Colin R. Marchus for training in cell culture.

The Effect of a 4-Week Tonal Strength Training Intervention on Body Composition, Muscular Strength, and Emotional Well-being on Premenopausal Working Mothers

E. Hill, S. Brooks, A.F. Brown
University of Idaho, Moscow, ID

ABSTRACT

BACKGROUND: Premenopausal working women with children are often overlooked in the fitness world, dismissed as being too busy to prioritize strength training. However, the benefits of strength training on physical and emotional well-being can impact mothers and promote longitudinal health. The Tonal at home fitness program gives pre-menopausal women the opportunity to incorporate strength training without the stress and time of going to the gym and arranging childcare. Many physical changes occur following pregnancy and the needs of a child win over self-care. However, a premenopausal working mother population has not been studied in conjunction with strength training. **PURPOSE:** This study aims to make not only fitness more accessible to premenopausal working mothers but encourage the incorporation of strength training into their workout routines. **METHODS:** Over 4 weeks, working female mothers with at least 1 child older than 6 months and under the age of 18 will be recruited to participate in workouts 4 times a week of varying focuses and intensities. Physical and emotional measures will be taken before and after to assess the differences that the Tonal program can have. **CONCLUSION:** This pilot study can open future opportunities for this specific population to be studied with strength training and the Tonal equipment.

INTRODUCTION

The female body undergoes significant body composition changes following pregnancy and throughout the midlife period, which can negatively impact health later in life. Because it is simple and inexpensive to assess, body mass index [BMI; body weight (kg)/height2 (m2)] is typically used to identify changes in body composition however, BMI does not capture relative amounts of muscle vs. adipose tissue. Following pregnancy, many females experience loss of muscle and accumulation of adipose tissue. Infiltration of fat into muscle tissue hides unhealthy body composition from notice. Previous findings from our laboratory have demonstrated that normal weight obesity (NWO; normal BMI and >30% body fat) is prevalent in young females that are physically active but do not engage in strength training (ST). NWO is of distinct concern for females following pregnancy because of hormone changes that lead to heightened fat mass storage[1]. Recent literature demonstrates that 55% of working mothers do not meet physical activity guidelines[2] and ST is often avoided by females for fear of "bulking" based on previous ideals of a feminine body[3]. Although females could greatly benefit from ST, it is often an avoided gym activity because of fear of misuse and embarassment[4]. Lack of confidence in ST abilities in combination with post-pregnancy body composition changes may contribute to dissatisfaction with both exercise experience and body image.

PURPOSE

The goal of this study is to assess the physical and psychological impact that strength training has on premenopausal working mothers. Specific Aim 1: Compare physical attributes of body composition, muscular strength, and cellular strength in working mothers following ST (strength training) intervention. Specific Aim 2: Compare the psychological attributes that include physical activity enjoyment and body satisfaction in working mothers following ST intervention.

METHODS

PARTICIPANTS: Participants between 18-50 years old will be recruited from the Moscow-Pullman area. Recruitment strategies include fliers posted throughout Moscow and advertisements on local Facebook groups. Participants must have at least 1 child between the ages of 6 months and 18 years old and be employed either full or part time. Exclusion criteria includes if participants are currently strength training (>20 min/day >2 days/week), are currently pregnant, have medical conditions contraindicating to exercise, are currently smoking or have a diagnosed eating disorder.

DATA COLLECTION: Participants will visit the Human Performance Lab (HPL) hand Vandal Muscle Lab 1 time prior to beginning training on the Tonal. This visit will consist of a DXA scan, Body Parts Satisfaction Scale (BPSS), Physical Activity Enjoyment Scale (PACES), Dietary Assessment (ASA-24) and baseline max testing using Tonal equipment (Fig 1). The ASA-24 assessment will be taken 1x per week over the 4 weeks of the study to ensure no significant changes in intake are occurring. Participants will complete workouts of varying focus each week lasting 30-60 minutes per day (Fig 2). Following the intervention, participants will visit the HPL and Vandal Muscle Lab, performing the same assessments as pre-testing.

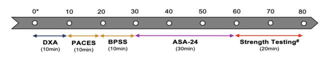


Figure 1. Human Performance Laboratory Pre-, Post-Testing Timeline *minutes; #includes familiarization at pre-testing; DXA = dual energy x-ray absorptiometry; PACES= Physical Activity Enjoyment Scale; BPSS= Body Parts Satisfaction Scale; ASA-24= Automated Self-administered 24-hour dietary recall.

Figure 2. Vandal Muscle Laboratory Weekly Tonal Strength Training Participants will complete 2 Whole Body Strength Training sessions, 1 Cardio session, and 1 Recovery session per week for 4 weeks. *Indicates ASA-24 dietary recall day.

METHODS CONT.

STATISTICAL ANALYSIS: Statistical analyses are completed using SPSS Statistics 24 and data were reported as mean±SD. Significance was accepted at $p<0.05$. A repeated measures analysis of variance (ANOVA) was used to assess the effect of time and group on each variable

PRELIMINARY RESULTS

Table 1. Nutritional Information

	(n=7)
KCALS	1670.6±636.8*
Protein (g/kg)	74.4±26.5170
Fat (g/kg)	82.5±36.9255
Carbs (g/kg)	140.1±59.7731

*Mean±SD, g/kg: grams per kilogram

Table 2. Body Composition Information

	(n=7)
Weight (kg)	75.5944±15.6004*
LM (kg)	47.3936±4.5342
LM (%)	63.9176±7.9128
FM (kg)	25.4316±11.7804
FM (%)	32.5857±8.2743
VAT (g)	457.1428±287.6273
ASMI kg/m^2)	7.1485±0.8029
BMD	1.1338±0.073

*Mean±SD, kg: kilograms, %: percent, g: grams, kg/m^2: kilograms over meters squared

DISCUSSION

This study will aim to reframe the stigma around women strength training and to encourage and implement strength training into mother's routines. The stigma around hypertrophy has prevented women from considering ST and the Tonal system allows them to explore fitness in the comfort of their own home. The convenience eliminates the time consuming and nerve-wracking barriers that come with a gym membership. The system helps to train and educate users on proper form and routine. We are hoping to see an increase in enjoyment of working out and a positive increase in body perception and body composition. This study is one of the first studying this specific population and will open the doors for future expansion of strength training studies on women, specifically working mothers.

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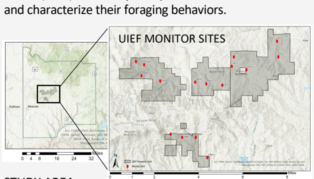
Using Acoustic Monitoring to Detect Bat Species in the University of Idaho Experimental Forest

Klara Isbell, Elyce Gosselin, Dr. Robert Keefe, Dr. Lisette Waits

UI Summer Undergraduate Research Fellowship (SURF) Program
Adele Berklund Undergraduate Research Scholar Award
Kenneth Hungerford Research Award

INTRODUCTION & OBJECTIVES

Acoustic monitoring is an emerging non-invasive technique[1] for studying bats, birds, dolphins, and other echolocating animals[2]. This study will analyze echolocation recordings collected in the UI Experimental Forest (UIEF) to identify bat species in northern Idaho and characterize their foraging behaviors.



STUDY AREA

- 8,300 acres
- Four units: West Hatter, East Hatter, Flat Creek, Big Meadow

MONITOR PLACEMENT

- Three habitat types: open, edge, narrow[3]
- 16 total monitors

METHODS

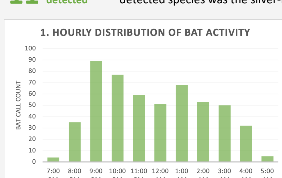
- Data collection (May 27-August 10, 2022)
  - Audiomoth monitors for collecting recordings[4]
  - Kaleidoscope Pro software for processing recordings and conducting an automatic species identification[5]
  - Manual species identification and verification

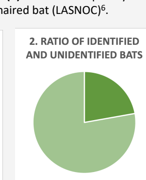
CURRENT RESULTS & SPECIES OBSERVED

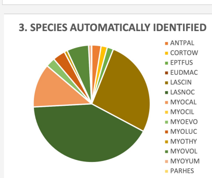
523 bat calls recorded

11 species detected

(1) The activity detected between May 27 – June 17th suggests a peak in activity between 9-10pm followed by a gradual decline. **(2)** Only 28.5% of bat calls received an automatic identification from Kaleidoscope. **(3)** The most frequently detected species was the silver-haired bat (LASNOC)[6].







Abbreviation	Common Name	# Recordings
ANTPAL	Pallid bat	3
CORTOW	Townsend's bat	2
EPTFUS	Big brown bat	2
EUDMAC	Spotted bat	0
LASCIN	Hoary bat	31
LASNOC	Silver-haired bat	48
MYOCAL	California myotis	14
MYOCIL	Western small-footed bat	0
MYOEVO	Long-eared myotis	3
MYOLUC	Little brown myotis	4
MYOTHY	Fringed myotis	1
MYOVOL	Long-legged myotis	7
MYOYUM	Yuma myotis	1
PARHES	Canyon bat	0

CONCLUSION

- According to the Kaleidoscope automatic identification, 11 species of bats were detected in the UI Experimental Forest. There are 14 species of bats native to Idaho[7].
- Most of the recordings require manual identification, and the automatically identified calls require verification by comparison with recordings from bat call libraries.
- There is more activity in the evening than morning. The peak activity time occurs between 9-10pm followed by a gradual decline with another peak between 3-4am.

FURTHER WORK TO BE COMPLETED

The data displayed here only represents recordings collected May 27th-June 17th, 2022. Data collection will continue through August 10th, 2022, after which detailed manual identification of recordings will be conducted. The objectives of this study are to create a species inventory and to analyze for potential seasonal changes. Patterns relative to weather will also be assessed.

WORKS CITED

The Cell Membrane Kre1 as a Cell Receptor for K1 Killer Toxin in Pathogenic Yeasts

Julia Major and Dr. Paul A. Rowley
University of Idaho, Department of Biological Sciences

BACKGROUND

Yeasts of the Fungal kingdom are single-celled eukaryotes, with some possessing the ability to produce antifungal proteins named "killer" toxins. Killer toxins provide an evolutionary advantage over competing yeasts by inhibiting growth and causing cell death. These antifungals are primarily studied in biomedical research for their potential applications against fungal pathogens resistant to current front-line therapeutics. Antifungal resistance is a common problem, a prime example being the growing drug resistance of *Candida* yeasts. It is estimated that 1 in 3 women will suffer from a vaginal yeast infection at least once in their life, caused by a *Candida* yeast. Azoles, currently the most commonly prescribed class of antifungal drugs to treat vulvovaginal candidiasis, are as much as 32% ineffective [1]. Additionally, in patients prescribed the azole fluconazole, an estimated 10% experienced adverse side effects [2]. Azoles are considered the most effective class of antifungals for vaginal candidiasis; yet, they are only 60% effective, and 25% of these infections are caused by highly drug-resistant yeasts (*C. glabrata)*. The other 75% are caused by other species of the *Candida* genus such as *Candida albicans* and *Candida auris.*

The first described killer toxin, named K1, was discovered when sterile filtered growth media derived from *Saccharomyces cerevisiae* (baker's/brewer's yeast) was shown to inhibit the growth of competing yeasts [3]. In yeast cells, K1 is processed into a mature toxin and secreted into the environment. Killer yeasts create zones of growth inhibition when inoculated onto a growth medium with a susceptible competing yeast. Recently, the Rowley lab has successfully inhibited the growth of 100% of *C. glabrata* strains and isolates from the human vagina using the K1 killer toxin [4].

Figure 1: Killer yeasts inhibiting the growth of competing yeasts on a sold growth medium. After incubation for 48 hours, visible zones of growth inhibition can be observed as halos around each killer yeast strain.

After initially binding to the cell wall, K1 attaches to Kre1, what's thought to be its secondary receptor on the cell membrane. Kre1 is a GPI anchored protein found in the membrane covalently attached to the cell wall. K1 kills cells by disrupting cell membrane function by forming ion channels specifically for cations [5]. The formation of ion channels allows for the efflux of potassium and possibly hydrogen ions, subsequently leading to apoptosis and cell death. It was previously found that *kre1Δ* cells are completely resistant to K1, and expression of *KRE1* restored sensitivity [6] To further test the relationship between *KRE1* and K1 intoxication, I will be taking the *KRE1* gene from a variety of different yeasts and inserting and integrating them into the UTR of *S. cerevisiae*. These modified yeasts will be exposed to K1 through killer toxin assays, and the effects observed. It is expected that the engineered yeasts will be susceptible to K1.

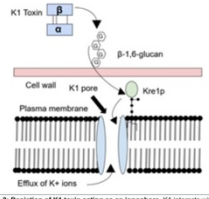


Figure 2: Depiction of K1 toxin acting as an ionophore. K1 interacts with β-1-6 glucan of *S. cerevisiae* yeast's cell wall. It is transported to the plasma membrane where it interacts with membrane receptor Kre1p, causing pore formation within the cell membrane

PRIMER DESIGN

Primers are short single stranded pieces of of DNA (usually 18-25bp long) designed for use in PCR (Polymerase Chain Reaction). I designed 9 different primers to amplify the *KRE1* gene of each yeast I was working with. PCR works in three major steps, denaturation, annealing, and elongation. Initially, the template DNA is denatured, and new DNA strands are synthesized, using the old strands as a template. Next, the primers anneal to the ends of the DNA strands, bracketing the region of interest. These strands are then elongated, and the process repeated 25-35 times, ending with a multitude of copies of the targeted gene. Using the NIH protein blast, I collected the nucleotide sequences of each ORF of every KRE1 in my 9 yeasts, plus -/+ 1 kb of the UTR. Primer3 was used to design the forward and reverse primers for each yeast's *KRE1* using the UTRs These yeasts were chosen due to the variance in size and species. Due to the pathogenic nature of yeasts in the Candida genus, they were not included in the intilal rounds of PCR, but will be used later.

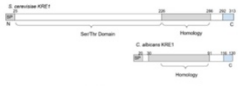


Figure 3. Domain diagram of KRE1 from *S. cerevisiae* and *C. albicans*. Depiction of KRE1 genes with noted areas of homology and high serine threonine; light blue areas represent the hydrophobic domain of the C terminal

Strain	Yeast
NBRC/IFO 10990	*Saccharomyces kudriavzevi*
SS5411	*Saccharomyces kudriavzevi*
NCYC_2729	*Kazachstania africana*
Y-17070	*Tetrapisispora phaffi*
2.3317	*Saccharomyces arboricolus*
CBS432	*Saccharomyces paradoxus*
CBS_12357	*Saccharomyces eubayanus*
Y_2379	*Torulaspora delbrueckii*
NCYC_777	*Naumovozyma dairenensis*
NCYC_2898	*Naumovozyma castelli*

Figure 4. 10 yeast with respective strains. Table detailing the full names and strains o f each yeast chosen for this project

PCR AND gDNA EXTRACTION

Before PCR could be done, the genomic DNA needed to be extracted from each yeast. Each of the 10 yeasts were grown overnight in 10 ml cultures. gDNA extraction involved three main steps, lysis, precipitation, and purification. Lysis allows the cell membrane to be broken down so that the DNA can precipitate out of the solution and separate from the other cellular components in the second main step. Lastly, the purification step is necessary to get rid of any residual salts, proteins, and the like. After resuspension of the gDNA in TE buffer, I ran PCRS with my previously designed primers to amplify the KRE1s. To ensure it was successful, the expected product sizes were calculated in, adding the length of the gene and the primers together.

Yeast	Expected product size
S. kudriavzevi	1129 base pairs
K. africana	617 base pairs
T. phaffi	1202 base pairs
S. arboricolus	1151 base pairs
S. paradoxus	1197 base pairs
S. eubayanus	1184 base pairs
T. delbruecki	1389 base pairs
N. dairenensis	1433 base pairs
N. castelli	1492 base pairs

Figure 5. Table of the 9 yeast species used in the project. Predicted produc size based on length of the specie's *KRE1* and primer length.

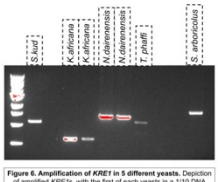


Figure 6. Amplification of *KRE1* in 5 different yeasts. Depiction of amplified KRE1s, with the first of each yeasts in a 1/10 DNA dilution, and the second in a 1/100 DNA dilution.

NEXT STEPS

Now that the *KRE1* of all 10 yeasts has been successfully amplified, the next step is to engineer a *KRE1* knockout strain of *S. cerevisiae* BY4741. Once this strain is made, new primers allowing for integration of orthologous *KRE1*s in *S. cerevisiae* will be made. These primers will target the KRE1s of the 10 respective yeasts, with homology to *S. cerevisiae's KRE1*'s UTRS to allow for integration into the cell. After successful integration, killer assays will be performed where the engineered yeasts are exposed to K1. We expect the yeasts to be susceptible to K1, regardless of the orthologous KRE1s. The same experimental process will be repeated for yeasts of the *Candida* genome, after sufficient Biosafety Level 2 training, due to their pathogenic nature.

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Phenotypic Heterogeneity of Polyhydroxybutyrate Production in *Methylobacterium extorquens*

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Department of Biological Sciences

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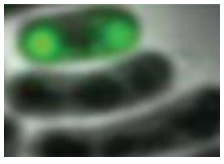
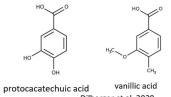
Introduction: Lignin is one of the most abundant organic materials on Earth; however, the resource is widely unused as a biofuel stock as it contains aromatics which are toxic in nature. Additionally, some aromatics offer a secondary source of toxicity in the form of methoxy groups that subsequently form formaldehyde when broken down. *Methylobacterium extorquens* was used for the microbial conversion of methoxylated aromatics into polyhydroxybutyrate (PHB). The production of PHB from methoxylated aromatics in *M. extorquens* is useful as a proxy for investigating potential 1-butanol production, as it follows the same carbon flow.[1] This project goes past population level PHB quantification and aims to quantify single cell PHB production using a combination of flow cytometry, fluorescent microscopy, and HPLC.



PHB granules (green) accumulate at different rates at the single-cell level. This can be viewed using a fluorescent microscope and Nile red staining.

M. extorquens Formaldehyde Resistance

Due to the natural formaldehyde resistance of *Methylobacterium extorquens*, it serves as a promising candidate for the microbial conversion of lignin to butanol.[2,3] However, the growth of *M. extorquens* on aromatics needs to be investigated further in order to optimize the potential production process.

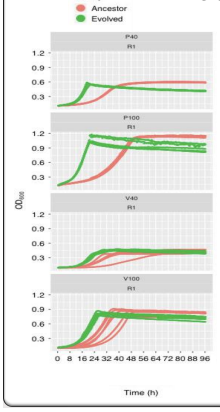


PCA (left) and VA (right). Note the methoxy group (CH_3-O) on VA as a source of secondary toxicity.

Methods

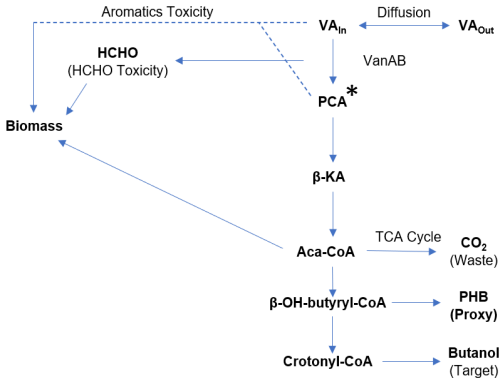
- Grow *M. extorquens* on respective evolved media
  - There are many strains of *M. extorquens* and those used in the Marx lab have been evolved to grow on carbon sources such as vanillic acid, methanol, and succinate.
- Extract PHB
  - Polyhydroxybutyrate (PHB) was used as a proxy for butanol as butanol is difficult to extract and quantify in relation to PHB.
- Quantify PHB production
  - Through HPLC
- Investigate for phenotypic heterogeneity of PHB production
  - Using flow cytometry and microscopy

M. extorquens Growth



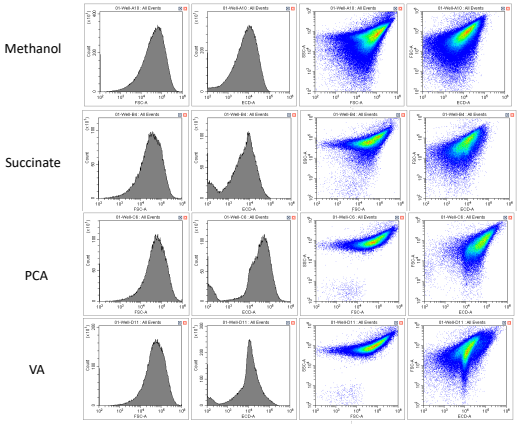
Growth curves showing the pattern of *M. extorquens* growth on respective media at varying carbon concentrations. Red depicts the ancestral strain while green represents the evolved strains.

- Evolved strains have larger initial growth rates
- Max growth rates remain the same between ancestral and evolved strains



VA catabolism in *M. extorquens*. Formaldehyde (HCHO) is derived from the enzymatic cleavage of VA (Vanillic Acid). Additionally, note that butanol follows the same carbon as the proxy PHB.
*PCA is created from the enzymatic cleavage of CH_3 from VA

Flow Cytometry



Flow cytometry on varying media at the same carbon concentration (40 mM C).

- Overall cell size (column one) reveals a normal distribution
- PHB production among cell size varies
  - While the general trend shows a positive correlation between cell size and PHB there is a sizable distribution of small cells with high PHB levels and large cells with low PHB levels

Conclusion:

- Growth of ancestral strains tend to lag behind evolved strains while the max growth rate remains equal
- Flow cytometry data suggests that there may be phenotypic heterogeneity in PHB production among cells of the same population

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EXPLORING THE ROLE OF SCAVENGER DECLINES ON SOIL MICROBIAL FUNCTION

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Introduction

- Globally, top predators/scavengers are in decline but the effects of their loss on ecosystem function remain difficult to predict[1].
- The emergence of a highly transmissible, lethal cancer (DFTD) is pushing Tasmanian devils to the brink of extinction but provides an ideal natural experiment[2].
- Because devils are the top scavenger in Tasmania, their decline may induce a trophic cascade but the effect on soil and ecosystem function is unknown.
- My research investigates the link between scavenger loss, microbial function, and soil biogeochemistry.

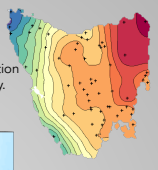
Healthy Tasmanian devil versus an individual with DFTD.

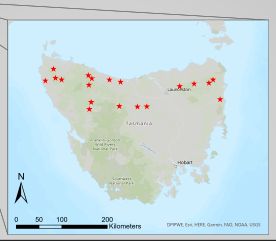
Hypotheses

- Devils do not affect soil pH or cation exchange capacity (CEC).
- Lower devil density increases soil C:N by inhibiting rapid cycling of non-plant inputs.
- Lower devil density reduces microbial diversity but increases total biomass.

★ Sample Sites

Sample sites spanning the East to West gradient of DFTD. Red = localized extinction while Blue = 95-100% of carrying capacity.





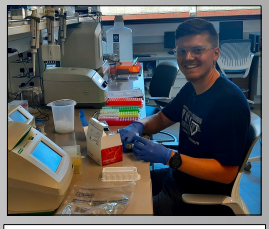
n = 19 sites with 3 replicates per site and 2 soil depths per replicate = 114 samples.

Driving Questions and Methods

Driving Questions	Methods
Does scavenger presence affect soil biogeochemistry and nutrient cycling?	Moisture Content Soil pH Soil fractions (MAOM & POM) Dissolved C & N pools Cation exchange capacity
Does the decline of a dominant scavenger alter soil microbial communities?	Microbial Biomass (C & N) DNA Extraction (bacterial 16S gene, fungal ITS1 region)

Future Work

- DNA extractions and soil moisture analysis has been completed
- Remaining analytical work will be completed this summer
- Statistical analyses, figure development, and manuscript writing will be completed in the next two semesters.



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Synthesis of substituted ATF ligands and their evaluation for metal dissolution and recovery from Waste electronic and electrical equipment (WEEE)

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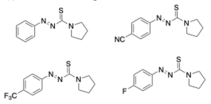
Abstract

The dissolution and recovery of metals from waste electronic and electric equipment is important because the demand of precious metals in industrialization has increased and the quantity of natural raw metals has decreased therefore increasing the costs. Extraction of these metals is also important because it helps with environmental legislation thus making it easier to dispose WEEE. This is considered the secondary source of metals. Precious metals are used in a wide range of electronic appliances like, phones, modems, and computers. The types of precious metals that are usually found in waste electronic and electric equipment are gold, copper, silver, and palladium. In this study, there will be the synthesis of substituted ATF ligands and evaluation for metal dissolution of waste electronic and electrical equipment. The process utilizes a mild redox-active ligand series (**a**zothio**f**ormamides or ATF) capable of dissolving metals and metal salts into ligand-metal coordinative complexes. These recovered complexes will undergo electrochemical processing to recover high purity metals and fresh ligand, providing a fully recyclable system.

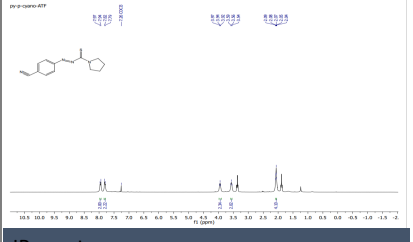
The recovery of metals from waste electronic and electric equipment has a positive impact on the environment because it reduces the toxic chemicals released by the WEEE into the atmosphere and reimagines how metals are sourced. The recovered metals can also be used for future industrial processes.

Background

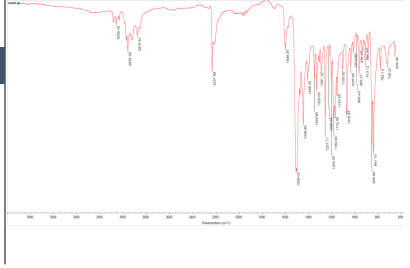
The ability of ATF ligands to chelate various copper species has been previously documented.[1] In addition to copper metal, 1:1 μ-X dimer crystals **3** form with copper(I)halides and 2:1 ligand to metal complexes are formed from copper(I) salts containing non-coordinative counterions (BF_4^-, PF_6^-) **4**.[2]



HNMR



IR spectrum



UV-Visible titration and Binding isotherm

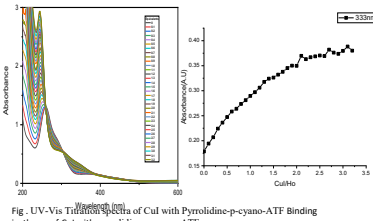


Fig . UV-Vis Titration spectra of CuI with Pyrrolidine-p-cyano-ATF Binding isotherm of CuI with pyrrolidine-p-cyano-ATF

Conclusion

The Pyrrolidine-p-cyano-ATF has a melting point of 73 degrees with a yield of 40%. Electron-donating moieties resulted in more exothermic interactions, larger extinction coefficients, and an increased predicted binding association whereas electron-withdrawing moieties provided weaker binding association

Acknowledgements

University Of Idaho Office of Undergraduate Research

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Assoc Prof Yew. "Recovering precious metals from e-waste" April 2016

Synthesis of Surfactant Templated Mesoporous Silica

Gabe Nelson, Dr. Mark F. Roll
University of Idaho, Moscow, ID

Introduction

- Arrays of silica nanochannels (ASNC) are a material that consists of an array of mesopores in a silica matrix
- ASNC are an important material with uses in fields such as:
  - drug delivery
  - thermal energy storage, and
  - filtration
- Surfactants are molecules used as a template for ASNC (Fig 1):
  - The most common surfactant is called CTAB
  - Surfactants self assemble into array of cylinders
  - TEOS is hydrolyzed by a catalyst to silicic acid, which condenses onto the surfactant array
  - The silica is stabilized and condensed by calcination, which removes the surfactant
- Structure is dictated by the surfactant template
- Surfactant removal technique can affect the final silica structure
- Nitrate catalyst can be attached to CTAB to make CTAN

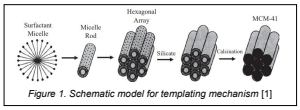

Figure 1. Schematic model for templating mechanism [1]

Results

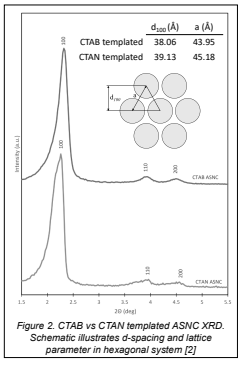

Figure 2. CTAB vs CTAN templated ASNC XRD. Schematic illustrates d-spacing and lattice parameter in hexagonal system [2]

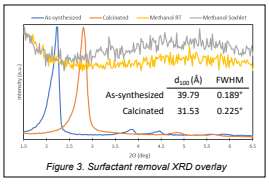

Figure 3. Surfactant removal XRD overlay

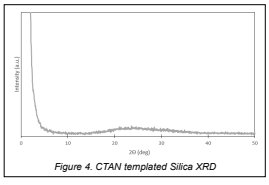

Figure 4. CTAN templated Silica XRD

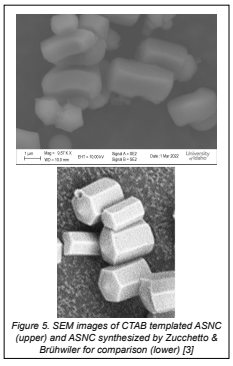

Figure 5. SEM images of CTAB templated ASNC (upper) and ASNC synthesized by Zucchetto & Brühwiler for comparison (lower) [3]

Methodology

CTAN synthesis
- Combine 1 g $AgNO_3$ and 2.2 g CTAB in 34 mL of water
- Precipitate AgBr byproduct in 90 mL methanol
- Let solvent evaporate to recover CTAN

ASNC synthesis
- Dissolve 4 g surfactant in 60 mL of 37% HCl and 76 mL of water
- Added 2 mL of TEOS to solution at 0 ºC
- Held at 0 ºC for 4 hours to form silica nanochannels
- Vacuum filtered and washed with 50 mL of water
- Did low-angle XRD and indexed peaks by analytical methods

Self-catalyzing CTAN templated silica
- Dissolved 2 g CTAN in 40 mL water
- Added 1 mL of TEOS to solution at room temperature
- Let stir for 16 days
- Isolate product with a methanol wash

Surfactant Removal
- Heated at 330 ºC for 2 h followed by calcination in air at 550 ºC for 18 h
- Washed 400 mg ASNC in 40 mL methanol at RT for 24 hours
- Ran 50 mL methanol through 200 mg ASNC in Soxhlet extractor for 24 hours

Objectives

- Synthesize CTAN surfactant
- Compare CTAN templated silica to CTAB templated silica
- Compare methanol surfactant removal techniques to calcination
- Use CTAN as a self-catalyzing silica template

Conclusions

- Qualitative observations from synthesis indicate successful CTAN production
- CTAB and CTAN templates produce very similar ASNC
- Calcination decreases d-spacing and increases peak breadth
- Methanol degrades structure at RT and in Soxhlet extraction
- Current self-catalyzing procedure produces disordered structure
  - May be due to methanol wash step degrading structure

Acknowledgements

This research was funded by an Undergraduate Research Grant from the Office of Undergraduate Research at the University of Idaho.

Future Work

- Infrared spectroscopy of synthesized CTAN
- SEM of CTAN templated ASNC
- Methanol free synthesis of CTAN-templated silica
- Ethanol based chemical surfactant removal
- ASNC synthesis with CTAC and F127 surfactant templates
- Gas adsorption analysis of all ASNC to determine:
  - Surface area
  - Pore size, and
  - Density

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2. Johansson, Emma M. Linköping University, Linköping, Sweden, 2010.
3. Zucchetto and Brühwiler. **RSC Adv.**, 2015,**5**, 74638-74644; https://doi.org/10.1039/c5ra16913e.

The Effects of Elevation and Evaporation on Soil Water Isotopic Composition Across the Cascades and Rocky Mountains

Charis Peever; Advisor: Elizabeth Cassel, Earth & Spatial Sciences

Background

The increasing effects of climate change are becoming apparent in yearly precipitation and evaporation rates, and this is affecting not only soil health, but also groundwater reservoirs (Konapala et al., 2020). An isotopic composition map constructed using soil water samples will be pivotal to understanding the rates of both precipitation and evaporation, and the distribution of areas that are and will continue to be affected by climate change. This isoscape will be useful as a baseline for current paleo-elevation studies, as it will be more accurate than isoscapes constructed with river water data, which is more prevalent and easier to collect, but skewed by water inputs from outside the local area. This isoscape will also be used to determine the amount of water being lost at various locations across the region due to evaporation. Soil water is a more accurate local sample than river water as soils tend to incorporate only local precipitation waters, much like the geologic proxy materials. It also averages rainfall over multiple years (Breecker et al., 2009).

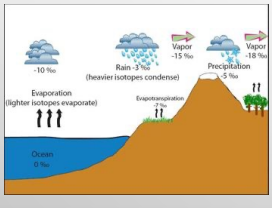

Fig. 1: Model of isotopes in precipitation showing a typical distribution of heavy mass isotopes (^{18}O, D) in relation to elevation changes and vapor introductions due to evaporation. Based on Hoefs (2009) and Bruckner (2022).

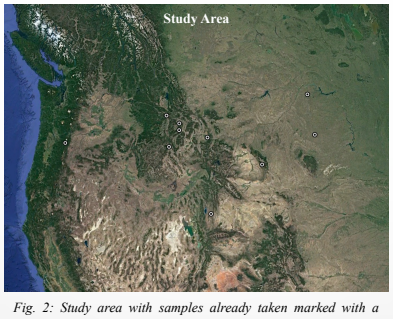

Fig. 2: Study area with samples already taken marked with a white and black dot. More samples are being taken to fill in blank areas, specifically in Idaho, Oregon, and eastern Montana.

Methods

Sample Collection: I will be digging a soil pit near each of the locations where volcanic glass is sampled for the paleo-elevation data for the most accurate comparison. At each soil pit, I will take a sample every 20 cm, up to 1 m depth, sealing the sample immediately to limit any evaporation due to air exposure. Sampling at multiple depths within the soil column will help in identification of evaporation trends (Breecker et al., 2009).

Soil Water Extraction: For preparing the samples, I will be using the cryogenic vacuum extraction line in Dr. Cassel's lab to extract all water from the soil sample, following the methods of Orlowski et al. (2018). Isotope ratio analysis of the extracted waters will be done at the University of Texas – Austin, where the samples will be analyzed for both δD and $\delta^{18}O$ values.

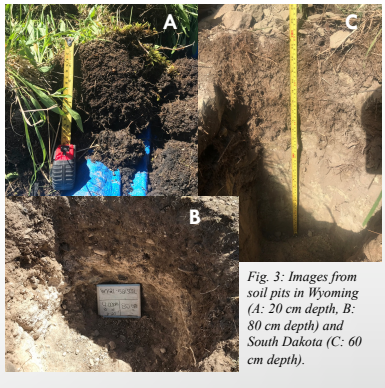

Fig. 3: Images from soil pits in Wyoming (A: 20 cm depth, B: 80 cm depth) and South Dakota (C: 60 cm depth).

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Project VineHeart Dashboard

Zachariah Preston – College of Engineering – University of Idaho

Abstract

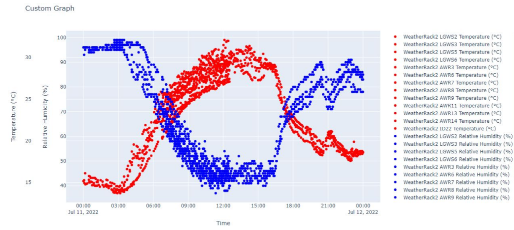
Project VineHeart is an enterprise to install various sensors throughout the Laurel Grove Wine Farm in order to monitor the vines and their environment. To use the collected data, a dashboard is needed for displaying visuals such as graphs, maps, and tables that convert the raw data into meaningful representations. This dashboard, hosted on a website, allows the users to analyze the data from different perspectives, such as real-time data shown on a map or comparisons of readings for different sensors. It also has a modular software structure that makes it easy to expand the dashboard and use the data in more ways than just a website. The dashboard will be a powerful tool for tracking the growth and quality of the vineyard and maintaining it for the future.

Introduction

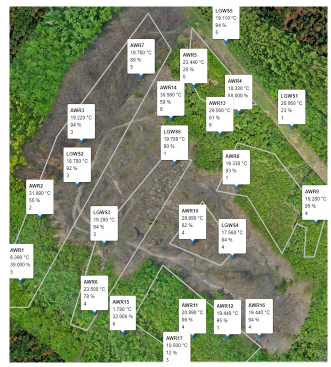
Laurel Grove Wine Farm is deploying sensors in their vineyard that record various qualities in the environment, such as temperature, humidity, soil moisture, rainfall, and more. The data collected by these sensors is transmitted via radio and aggregated into a MongoDB database. From here, the data needs to transformed into representations that are informative for the users, and give them insight on the overall status of the vineyard as well as details about each sensor's area. So, a dashboard was implemented that queries raw data from the database and uses it to construct visualizations. It's accessible from a website so that the vineyard data can be checked at any time. A variety of filters and customization options are provided as well, which makes it easy to find details about any aspect of the vineyard.

Structure

The software structure for the dashboard has a modular design to allow the program to be expanded upon in the future. The website has a driver that gets its data by sending a request to a central controller. Then, the controller forwards this request to the corresponding database for the data (MongoDB in this case). The database driver converts the request into a database query and searches for the data. Once it has the data, it's sent back to the controller, which passes it on to the website driver. With this setup, new databases can be added to the project by simply creating an additional driver. It also gives the option of using the databases for creating interfaces in addition to the dashboard.



Field	Value	Units	Field Type
Average Wind Speed	1.3		[A] Weather
Last Gust Wind Speed	1.7	m/sec	[A] Weather
Wind Direction	0	degrees	[A] Weather
Cumulative Rainfall	636.6	mm	[A] Weather
Temperature	26.06	°C	[A] Weather
Relative Humidity	23	%	[A] Weather
Visible Sunlight	131069	lx	[A] Weather
Ultraviolet Light	8.3	UV scale	[A] Weather
Dew/Frost Point Estimate	3.302807069691901	°C	[A] Weather
Date of Last Rain	May 26 2022		[A] Weather
Time	2022-06-19T17:44:15.000000		[B] Data Info
Integrity Code	CRC		[B] Data Info
Gateway ID	1		[B] Data Info
Model	SwitchDoc Labs FT020T AIO		[C] Sensor
Serial Number	12		[C] Sensor
ID	77		[C] Sensor
Low Battery Signal	False		[C] Sensor
[Signal] Modulation Type	ASK		[D] Signal
[Signal] Frequency	433.925	MHz	[D] Signal
[Signal] Strength	-11.032	dBm	[D] Signal
[Signal] Strength-to-Noise Ratio	6.171	dBm	[D] Signal
[Signal] Noise	-17.203	dBm	[D] Signal
Latitude	39.13828124991942		[E] Location
Longitude	-78.3308279697832		[E] Location
Altitude (orthometric height)	293.52		[E] Location



Tech Stack

The dashboard was built using the Dash web framework developed by Plotly. Dash makes it simple to set up a website and start adding features. All of the HTML and JS for the site is implemented by Python objects and callback functions, so the code for each web page is all in one place and easy to maintain. For styling, Dash Bootstrap provides components that all match a selected theme, and has a simple grid system for arranging the content on the page. Dash also includes Plotly's graphing interface, so it's easy to generate and display graphs on the page. The interactive maps are made using Dash Leaflet, a wrapper for the React-Leaflet JS library. Images are rendered on these maps by converting them to tile maps with gdal2tiles. The website is hosted on Amazon Web Services so that it can be accessed at any time with a URL.

Layout

Each page on the website gives a different view of the data. The "Home" page has quick access to graphs that are frequently needed. The "Real-Time Data" page uses Leaflet to show the location of each sensor and their most-recent data. It also generates alerts for the sensors to signal potential problems, such as a low battery or no data received in the past day. The "Sensor Data" page gives detailed information and graphs about individual sensors. This information includes tables with real-time data for that sensor, graphs of the data over time, and aggregations of the sensor's data such as averages and maximums. Finally, the "Custom Graphs" page has a wide range of parameters and settings for comparing any combinations of sensors and data fields. These graphs can be customized and saved on the website to view at a later time.

Conclusion

The Project VineHeart dashboard is a robust interface for analyzing the vineyard at Laurel Grove Wine Farm. The options that it provides give a multitude of ways to interpret the conditions of the vines and their environment. The benefit of the dashboard is more-informed decisions when taking care of the vines, and maintaining the land and air where they grow. This dashboard is just one step in the sequence for the utilities and services provided by Project VineHeart.

Exploring the structure-function relationship of killer toxin immunity

University of Idaho
Department of Biological Sciences

David C. Reetz, Marty Ytreberg, Jack Creagh, and Paul A. Rowley

Background: Killer yeasts, K1, and modeling approaches

- Harmful fungi affect millions of people every year
- Responsible for a significant portion of global food spoilage [1].
- Antifungal agents are challenging to develop

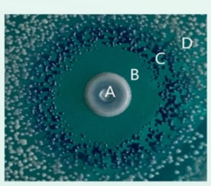


Fig 1. Killer yeast effect on susceptible yeast

- Killer yeasts secrete killer toxins (KTs)
- Kill other yeasts, create an inhibition zone
- Common Brewer's yeast
- Killer Assay (Left)

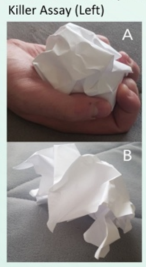


Figure 3: Representation of energy minimization

A. crumpled paper representing unoptimized AlphaFold model.

B. Relaxed paper representing energy optimized model.

- little structural or mechanistic data on KTs.
- Protein prediction tool AlphaFold2 - reliable structures in minutes.[2]
- processed using GROMACS
- molecular dynamics simulator and the results can be tested in the lab.
- 22 KTs were modeled and optimized

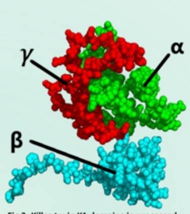


Fig 3. Killer toxin K1 domains in processed model

- K1 is a killer toxin
- Effective on C. glabrata[3]
- Best studied killer toxin
- Three distinct domains
- Toxin, Immunity, Targeting.
- Gamma Cleavage

K1, K1L, and KKT toxin modeling

- Alpha and gamma domains interact – Chaperone immunity.[5]
- Flexible glycine chain model for docking predictions.[6]
- Interactions between the two chains shown below

Fig 4. K1's alpha and gamma domains are predicted to interact closely. Processed AlphaFold2 model of K1 alpha and gamma domains directly connected, (Left) Processed AlphaFold2 model of K1 alpha and gamma domains modeled with 19 Gly residues, (Right) [8]

- Homologs can build confidence
- K1L – K1 like killer toxin – 18% sequence identity
- KKT family - 16-28% sequence identity [7]
- Similar interaction between gamma and alpha of related proteins – builds confidence in interaction

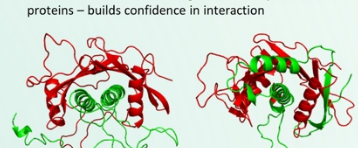


Fig 5. High structural similarity and immunity motif preserved between K1L and the KKT genes. Processed model of K1L (*S. paradoxus*) alpha and gamma domains (right) Processed model of KaKKT1 (*K. Africana*) alpha and gamma domains (left). Alpha and gamma domains for both toxins have been selected based upon likely cleavage sites and similarity in length to K1's domains.

Testing the interaction between the alpha and gamma domains of K1

- Yeast 2 hybrid system selected for testing interaction
- Yeast grows on selective media if interaction is present

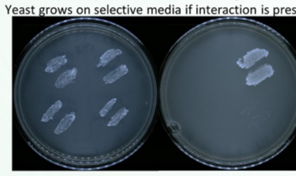


Fig 6. Yeast 2 Hybrid controls Strong interaction present

- Two plasmids must be constructed
- Gateway Cloning System
- Alpha and gamma each connected to proteins that induce expression when in proximity
- Expression of HIS3, URA2, and B-galactosidase proteins.

Fig 7. An agarose gel with PCR of the alpha domain and restriction digests of the gamma domain inside of the pCR8 Gateway donor vector. Wells 5-9, 11, and 12 have insert present.

Project Direction:

- Finish Yeast 2 Hybrid assays
- Repeat with K1L and KKTs
- In the event of failure:
- X-Gal, URA3, HIS2 (weak)
- Autoimmunity Assay
- New plasmids to construct

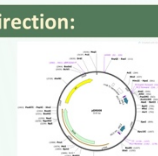


Fig 8. A vector map of the alpha donor

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Open Chromatin Regions and RNA Expression in Multiple Tissues from Angus Cattle

AUTHORS
Julia Woods, Gabrielle Becker, Katie Shira, Morgan Stegemiller, Stephanie McKay, Ph.D., Brenda Murdoch, Ph.D.

AFFILIATIONS
University of Idaho
Office of Undergraduate Research

INTRODUCTION

Our understanding of the epigenetic landscape in livestock animals is considerably less than within model species[1]. Epigenomic data is more notably important in agricultural animals due to the beneficial effect that the understanding of the pathway between genome and phenome can have on quality production[2]. To address this need for epigenomic data, organizations such as the FAANG Consortium have put forth efforts in filling informational gaps[1]. To aid in these findings, this project will provide necessary information on the relationship between open chromatin regions and RNA expression found in three tissue types of Black Angus cattle. To do so, two complementary sequencing assays will be used: ATAC-seq and RNA-seq. The findings from these assays will be analyzed and the results will be overlaid to help us better describe the epigenetic landscape in cattle.

OBJECTIVE

Aid in the **characterization** of the **bovine epigenomic landscape** to contribute to the betterment of livestock production

METHODOLOGY

Animal and Tissue Collection:
- Three target tissues: liver, muscle, and the frontal cortex
  - Four biological replicates
    - 2½ month old Angus calves
- Flash frozen and stored in -80°C until analysis

RNA Extraction:
- Samples homogenized utilizing a chilled mortar and pestle
- Purified using the Quick RNA MiniPrep Plus kit from Zymo Research
  - Nanodrop for quantification & quality measurements

RNA Sequencing:
- RNA-seq → LC Sciences
  - mRNA Poly-A total library prep and sequencing
    - NovaSeq reads 150bp paired-ends for a 40 M sequencing depth

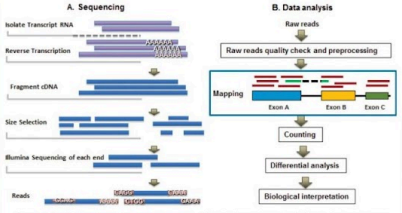


Figure 1. Depicted above is the general process RNA samples undergo in RNA-seq and subsequent analysis. Figure from "Bioinformatics for RNA- Seq Data Analysis" open source article.

ATAC Sequencing:
- ATAC-seq → Center for Epigenetics at UC San Diego
  - 100 mg aliquots of tissue
- Utilize the Tn5 transposase enzyme to cleave DNA at accessible regions
  - Insertion of a primer sequence
- Primed DNA is sequenced
  - Reads can be analyzed to identify regions of increased accessibility and possible transcription factor binding regions

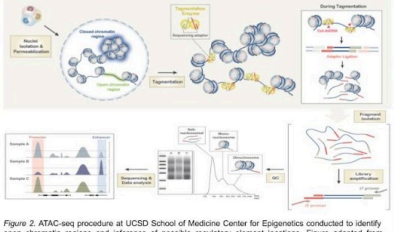


Figure 2. ATAC-seq procedure at UCSD School of Medicine Center for Epigenetics conducted to identify open chromatin regions and inference of possible regulatory element locations. Figure adapted from https://medschool.ucsd.edu/som/cmm/research/epigenomics/Pages/High-Throughput-Epigenomics.aspx.

Methods for Data Analysis:
- ATAC and RNA sequences:
  - Trimmed
  - Mapped to the bovine reference genome ARS-UCD1.3
- Analyses
  - Sequence peaks will be called using MACS2 for ATAC
  - Signal proximity will be examined
  - Analyzed and visualized in R

EXPECTATIONS

Through characterizing the transposase-accessible and actively transcribed regions of the genome of four biological replicates and three tissue types, we expect to define tissue-specific signal as well as capture biological variation. The results of this study will contribute to the current understanding of chromatin accessibility profiles in economically important livestock breeds. A previous study examined the liver, muscle, and hypothalamus in *Bos indicus* cattle. Their findings showed increased open chromatin regions in the hypothalamus, covering 2.41% of the genome[2]. Liver and muscle covered 0.52% and 0.98% respectively[2]. It was discovered that proximity of regulatory enhancers decreases in tissue-specific open chromatin regions, indicating a long range modulation of transcription. In this ongoing work, we expect to provide significant impacts and verification of the epigenome in relevant species of the livestock genetics community[2].

ACKNOWLEDGEMENTS

I would like to thank my mentor Dr. Brenda Murdoch for all her generosity and guidance throughout my time working with her. Thank you to the kind graduate students within my lab who have supplied me support and encouragement. Finally, I would like to thank the University of Idaho's Office of Undergraduate Research for presenting me with the Summer Undergraduate Research Fellowship grant that allowed me to make this research and presentation possible.

RELATED LITERATURE

1. The FAANG Consortium., L. Andersson, A.L. Archibald *et al.* Coordinated international action to accelerate genome-to-phenome with FAANG, the Functional Annotation of Animal Genomes project. *Genome Biol* **16**, 57 (2015). https://doi.org/10.1186/s13059-015-0622-4
2. Alexandre, P.A., M Naval-Sánchez, M. Menzies *et al.* Chromatin accessibility and regulatory vocabulary across indicine cattle tissues. *Genome Biol* **22**, 273 (2021). https://doi.org/10.1186/s13059-021-02489-7

Determining the stress response of dairy calves when transported at different ages

E. Worley, G. Chibisa, L. Gilbertson, Animal Science Department, University of Idaho

Introduction

- Under current production practices in the United States, transportation is one of the most devastating events that dairy calves face (Hulbert and Moisá, 2016).
- This not only affects the calves in the moment, but it can also impact their future growth and performance, and reduce profits.

Why?

- Currently, there are no regulations on when calves can be transported in the United States.
- However, there are indications that the negative impact of transport-related stress is more severe for younger than older calves.
- Without sound recommendations on the ideal age to transport calves, we will continue to have a high rate of diseases and deaths related to transport stress.
- Therefore, the objective of this study is to determine the impact of transporting Holstein bull calves that are 2, 4, 8 and 14 days old on growth performance, heart and respiration rate and blood cortisol concentration.

What is the best age to transport dairy calves?

Materials and Methods

- We will measure the impact of transporting Holstein bull calves of four distinct age groups: 2, 4, 8 and 14 days old on:
  1. Body weight
  2. Heart and respiratory rate
  3. Blood cortisol concentration
- For each age group, there will be 9 calves, making the total number of calves being collected 36.
- Calves will be transported for eight hours. Body weight will be measured upon arrival at the university facilities. Heart and respiratory rates will also be measured on arrival. A blood sample will also be collected at arrival for cortisol analysis.

Significance of the Project

With this study, we will create new evidence-based recommendations for the ideal age to transport calves. Therefore, we can increase the sustainability of dairy operations, as well as increase the production efficiency of dairy cows in the future.

Literature Cited

Hulbert, L. E., and S. J. Moisá, 2016. Stress, immunity, and the management of calves. J. Dairy Sci. 99:3199-3216. doi: 10.3168/jds.2015-10198

Acknowledgments

This project was supported by the SURF program

Special thanks to the University of Idaho Animal Science Department, Dr. Chibisa and Lauren Gilbertson

Final Report for HERC Funding for the 2022 Idaho Conference on Undergraduate Research (ICUR)
Submitted by Donna Llewellyn, Executive Director of the Boise State Institute for Inclusive and Transformative Scholarship

ICUR 2022 was held on July 20 and 21, 2022. Due to uncertainties related to COVID-19, the conference was an online event with optional closing receptions at each of the three research universities. We used the Fourwaves platform for the display of student posters and a synchronous poster fair and Zoom for synchronous talks and workshops. In terms of attendance, the participation was robust, although a small bit lower than last year. We utilized the funding from HERC to allow each research university to reserve space and technology along with catering to host a local optional closing reception. Note that due to the timing of the invoices for these events, that we ended up using IFITS' local funds to pay for these events so that those expenses do not show up in the budget below after all. In addition, once again, we purchased a license to use the Fourwaves site and we needed a much greater amount of staff time to get the conference designed, planned, and implemented. We are grateful for the HERC funding that allowed us to hold ICUR this year in spite of the uncertainty that existed during our planning process around large in person events at Boise State.

There were 481 people who registered for the conference this year, with 344 participating in the Zoom sessions. This included people from over 30 different institutions/organizations. There were 194 poster presentations with a total of 553 project collaborators including 249 undergraduate students, 84 graduate students and 161 faculty (plus some postdoctoral fellows, high school students, and other community members). Our planning committee of representatives from the different colleges and universities across the state really worked hard to encourage and facilitate participation.

There were two days of workshops and presentations – see the following pages for the program schedule. More details are also available at https://www.boisestate.edu/icur/. Note that Boise State has disallowed the use of pdf programs due to accessibility issues so all materials for the conference were posted at the event google site.

A survey was been sent out to all of the attendees. The likert scale responses and an overview of the open-ended responses are attached. We intend to use these results to improve the conference next year, as we learn from our virtual conferences about what aspects of this event are best suited to a virtual setting and which parts really suffer from a lack of in-person interaction.

The funding from HERC went to the following categories of expenditures:

Item	Amount
Online platform for poster displays and synchronous poster fair (will use this throughout the year)	15000.00
Other expenses related to online conference	675
Materials and Supplies	258
Admin, Evaluation, and Director Support	22,281.23
TOTAL	**$38214.23**

ICUR 2022 Schedule At-A-Glance

Access links to all virtual sessions will be available by visiting the schedule page of the Fourwaves ICUR 2022 site (update with link when it is live). *Note: You must be logged into Fourwaves* and *registered for ICUR 2022 in order to view the virtual session links.*

Day 1	Wednesday, July 20
10:00 a.m. MT	**Opening Session**
10:45 a.m. MT	Break
11:00 a.m. MT	**Undergraduate Lightning Talks**
12:15 p.m. MT	Lunch
1:30 p.m. MT	**Networking: Meet a Professor**
3:00 p.m. MT	Break
3:15 p.m. MT	**Panel Discussions** Panel Room 1: The Grad School Journey - grad students talk about their pathway to grad school and how to prepare and what to expect Panel Room 2: Recent grads who are working in industry - how did their UG research experience feed into their jobs
4:15 p.m. MT	**Closing Session** (including prize drawing)

Day 2	Thursday, July 21
09:30 a.m. MT	**Paired Research Talks**
11:00 a.m. MT	**Research Conversations** *Zoom Breakout Rooms with all attendees assigned at random*
12:00 p.m. MT	Lunch
01:00 p.m. MT	**Zoom Gathering for Instructions and Introduction** **Live Poster Sessions A and B** *Virtual Walk-Up Poster Session using Fourwaves Platform* A: Group A posters are presented *1:00 p.m. MDT to 2:00 p.m. MDT* B: Group B posters are presented *2:00 p.m. to 3:00 p.m. MDT* <insert link of which posters are in which groups when that is set>
03:15 p.m. MT	**ICUR Closing Session**

Access links to all virtual sessions are available by visiting the schedule page of the Fourwaves ICUR 2022 site (update with link when it is live). *Note: You must be logged into Fourwaves* and *registered for ICUR 2022 in order to view the virtual session links.*

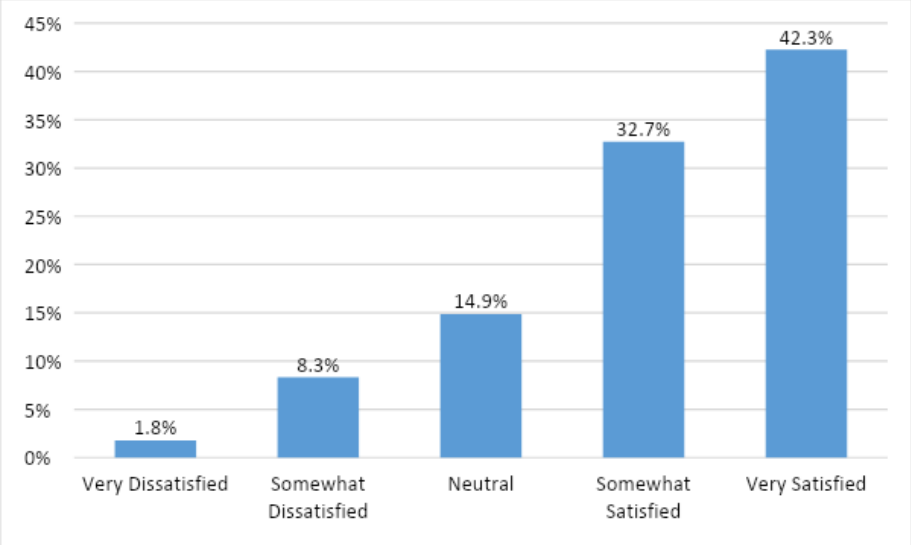
Idaho Conference on Undergraduate Research 2022
Survey Results

RESPONSE RATE: 35.3%

- 476 survey recipients (excludes 4 IFITS staff who did not receive the survey)
  - 304 (63.9%) students
  - 172 (36.1%) faculty/staff/other

- 165 recorded responses; 6 of these are incomplete responses
  - 3 of the incomplete responses answered no questions and are therefore EXCLUDED from analysis.

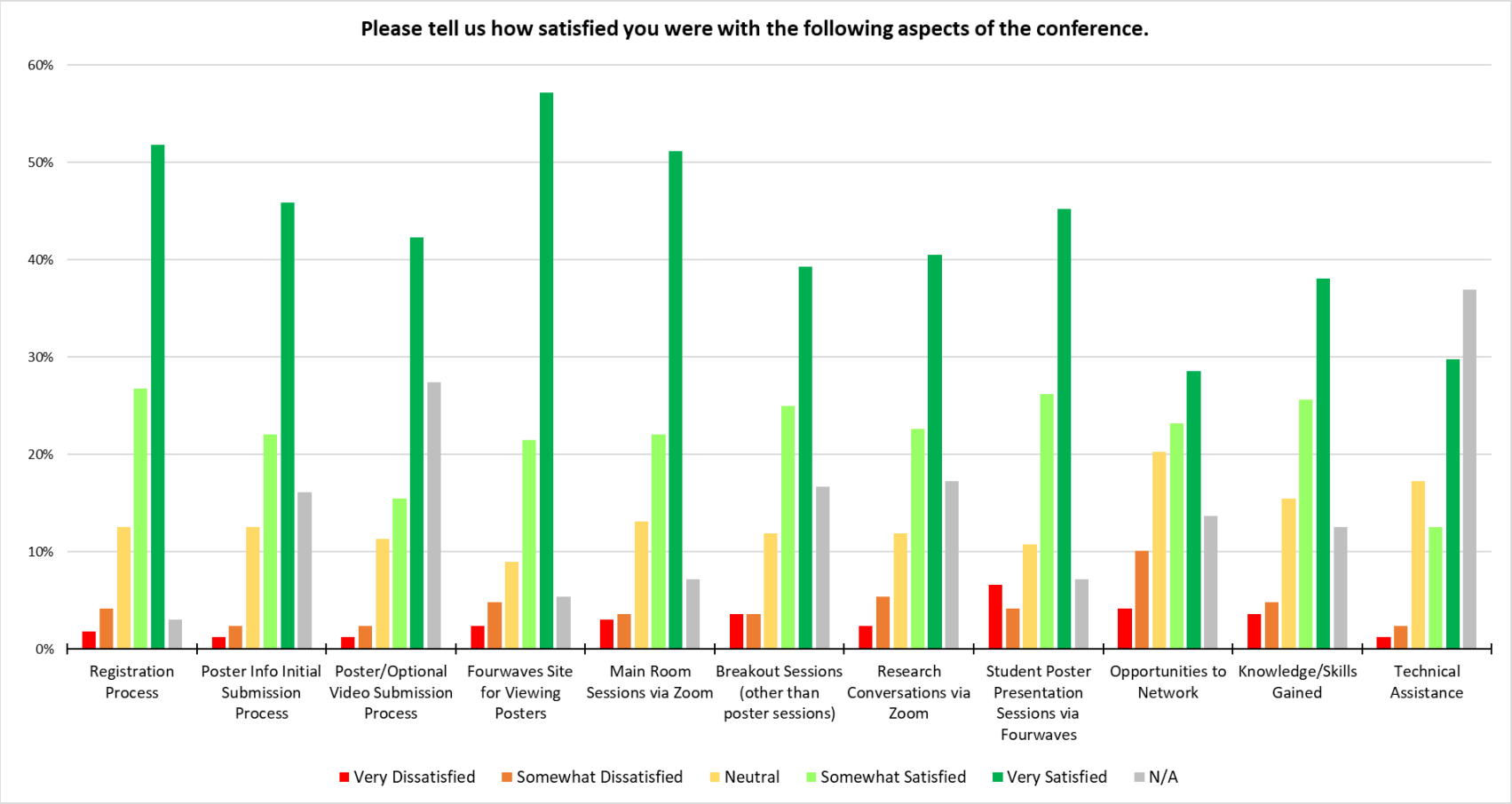
Please indicate your overall satisfaction with the 2022 Idaho Conference on Undergraduate Research.



Answer	%	Count
Very Dissatisfied	1.8%	3
Somewhat Dissatisfied	8.3%	14
Neutral	14.9%	25
Somewhat Satisfied	32.7%	55
Very Satisfied	42.3%	71
Total	100.0%	168

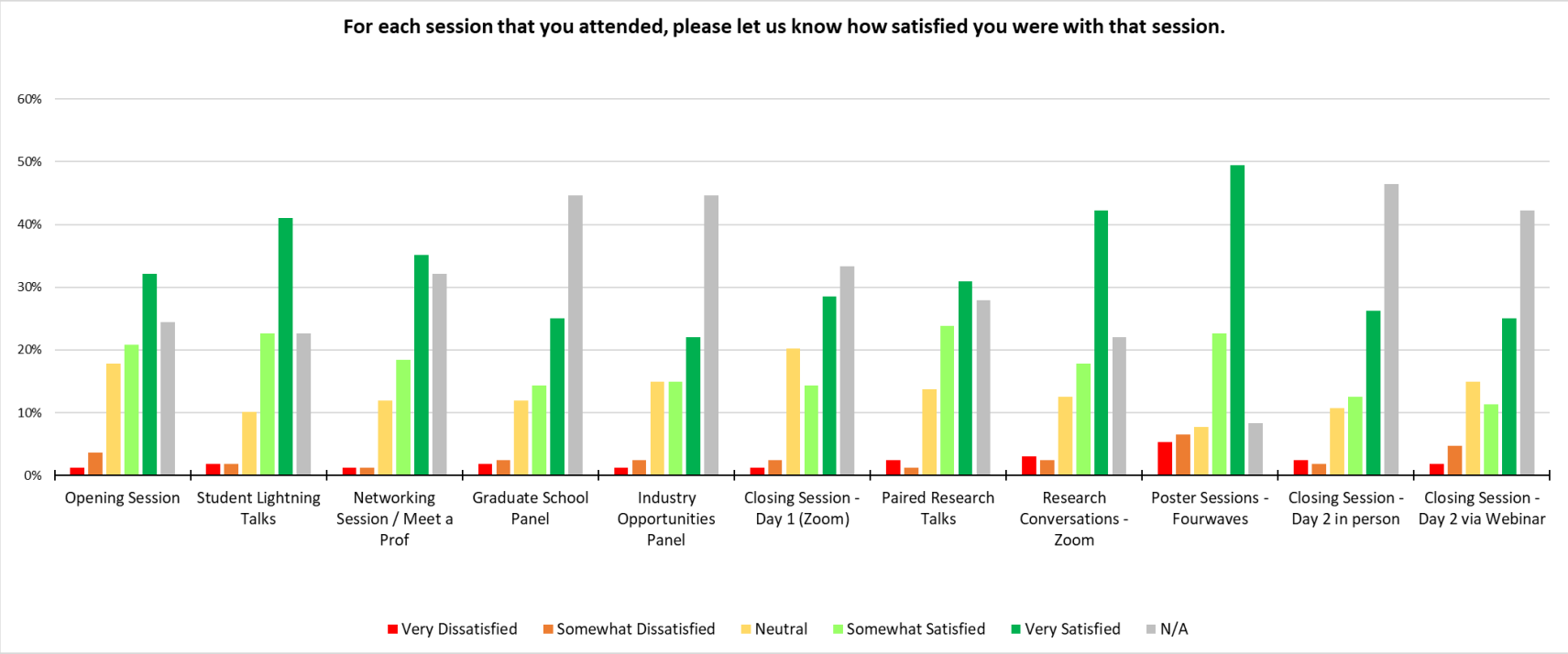
Please tell us how satisfied you were with the following aspects of the conference.

	Very Dissatisfied		Somewhat Dissatisfied		Neutral		Somewhat Satisfied		Very Satisfied		N/A		Total	
Aspect	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**
Registration Process	2%	3	4%	7	13%	21	27%	45	52%	87	3%	5	100%	168
Poster Info Initial Submission Process	1%	2	2%	4	13%	21	22%	37	46%	77	16%	27	100%	168
Poster/Optional Video Submission Process	1%	2	2%	4	11%	19	15%	26	42%	71	27%	46	100%	168
Fourwaves Site for Viewing Posters	2%	4	5%	8	9%	15	21%	36	57%	96	5%	9	100%	168
Main Room Sessions via Zoom	3%	5	4%	6	13%	22	22%	37	51%	86	7%	12	100%	168
Breakout Sessions (other than poster sessions)	4%	6	4%	6	12%	20	25%	42	39%	66	17%	28	100%	168
Research Conversations via Zoom	2%	4	5%	9	12%	20	23%	38	40%	68	17%	29	100%	168
Student Poster Presentation Sessions via Fourwaves	7%	11	4%	7	11%	18	26%	44	45%	76	7%	12	100%	168
Opportunities to Network	4%	7	10%	17	20%	34	23%	39	29%	48	14%	23	100%	168
Knowledge/Skills Gained	4%	6	5%	8	15%	26	26%	43	38%	64	13%	21	100%	168
Technical Assistance	1%	2	2%	4	17%	29	13%	21	30%	50	37%	62	100%	168


Please tell us how satisfied you were with the following aspects of the conference.
60%
50%
40%
30%
20%
10%
0%
Registration Process
Poster Info Initial Submission Process
Poster/Optional Video Submission Process
Fourwaves Site for Viewing Posters
Main Room Sessions via Zoom
Breakout Sessions (other than poster sessions)
Research Conversations via Zoom
Student Poster Presentation Sessions via Fourwaves
Opportunities to Network
Knowledge/Skills Gained
Technical Assistance
Very Dissatisfied
Somewhat Dissatisfied
Neutral
Somewhat Satisfied
Very Satisfied
N/A

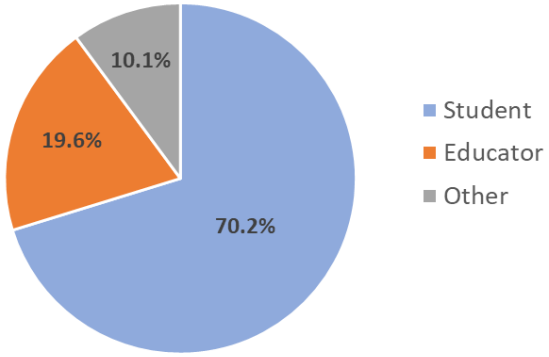
For each session that you attended, please let us know how satisfied you were with that session.

	Very Dissatisfied		Somewhat Dissatisfied		Neutral		Somewhat Satisfied		Very Satisfied		N/A		Total	
Session	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**
Opening Session	1%	2	4 %	6	18 %	30	21 %	35	32 %	54	24 %	41	100%	168
Student Lightning Talks	2%	3	2 %	3	10 %	17	23 %	38	41 %	69	23 %	38	100%	168
Networking Session / Meet a Prof	1%	2	1 %	2	12 %	20	18 %	31	35 %	59	32 %	54	100%	168
Graduate School Panel	2%	3	2 %	4	12 %	20	14 %	24	25 %	42	45 %	75	100%	168
Industry Opportunities Panel	1%	2	2 %	4	15 %	25	15 %	25	22 %	37	45 %	75	100%	168
Closing Session - Day 1 (Zoom)	1%	2	2 %	4	20 %	34	14 %	24	29 %	48	33 %	56	100%	168
Paired Research Talks	2%	4	1 %	2	14 %	23	24 %	40	31 %	52	28 %	47	100%	168
Research Conversations - Zoom	3%	5	2 %	4	13 %	21	18 %	30	42 %	71	22 %	37	100%	168
Poster Sessions - Fourwaves	5%	9	7 %	11	8%	13	23 %	38	49 %	83	8%	14	100%	168
Closing Session - Day 2 in person	2%	4	2 %	3	11 %	18	13 %	21	26 %	44	46 %	78	100%	168
Closing Session - Day 2 via Webinar	2%	3	5 %	8	15 %	25	11 %	19	25 %	42	42 %	71	100%	168


For each session that you attended, please let us know how satisfied you were with that session.
60%
50%
40%
30%
20%
10%
0%
Opening Session
Student Lightning Talks
Networking Session / Meet a Prof
Graduate School Panel
Industry Opportunities Panel
Closing Session - Day 1 (Zoom)
Paired Research Talks
Research Conversations - Zoom
Poster Sessions - Fourwaves
Closing Session - Day 2 in person
Closing Session - Day 2 via Webinar
Very Dissatisfied
Somewhat Dissatisfied
Neutral
Somewhat Satisfied
Very Satisfied
N/A

Please select your role.

Answer	%	Count
Student	70.2%	118
Educator	19.6%	33
Other	10.1%	17
Total	100.0%	168

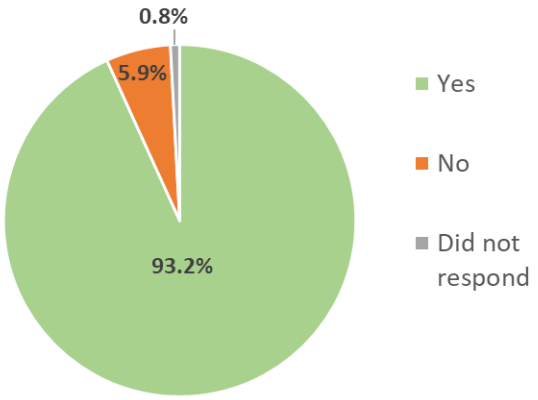


Other roles reported:

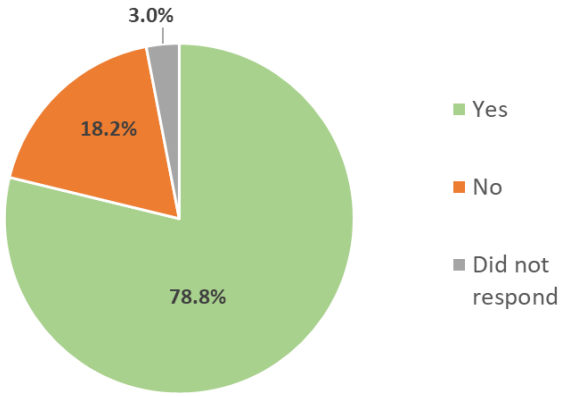
- Administrator
- Alumni
- Educator
- Family/friend
- Industry
- Postdoc
- Staff
- Student

Did you present a poster? (This question presented only to the respondents who selected "Student" as their Role.)

Answer	%	Count
Yes	93.2%	110
No	5.9%	7
Did not respond	0.8%	1
Total	100.0%	118

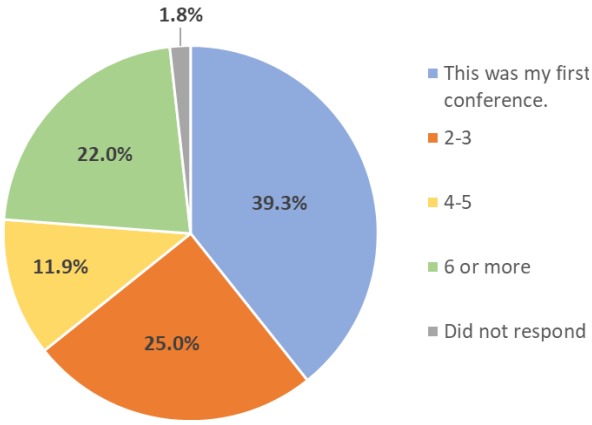


Were you a mentor of a student researcher who presented a poster? (This question presented only to the respondents who selected "Educator" as their Role.)



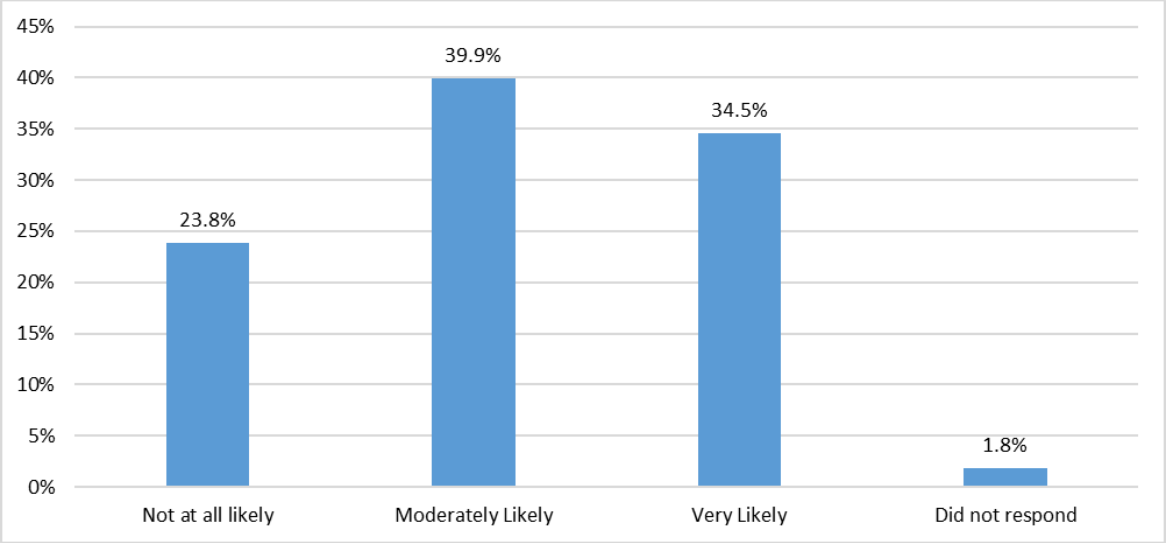
Answer	%	Count
Yes	78.8%	26
No	18.2%	6
Did not respond	3.0%	1
Total	100.0%	33

How many conferences (technical and professional conferences) have you attended including this one?



Answer	%	Count
This was my first conference.	39.3%	66
2-3	25.0%	42
4-5	11.9%	20
6 or more	22.0%	37
Did not respond	1.8%	3
Total	100.0%	168

How likely are you to attend ICUR next year?



Answer	%	Count
Not at all likely	23.8%	40
Moderately Likely	39.9%	67
Very Likely	34.5%	58
Did not respond	1.8%	3
Total	100.0%	168

How did you find out about ICUR?

The following table summarizes categories mentioned in the open-ended responses to this question and the count of respondents who mentioned them. The summary is sorted by the greatest number of mentions to the lowest. 138 respondents answered to this question; 8 mentioned more than one take-away. The sum of the category counts is 146.

CATEGORIES OF COMMENTS	COUNT
Specific faculty or staff member	31
REU program	20
SARE	14
Student	8
Advisor	7
I have previously attended	7
Office of Undergraduate Research (not necessarily BSU)	7
Student research participation (not specified)	7
Email	5
From the university/school (no specifics given)	5
HERC	5
Grant (not specified)	4

Internship	3
McNair Scholars	3
Not specified	3
Project SEED	3
Website	3
B2B	2
INBRE	2
SRC	2
Announcements (not specified)	1
Friend/family	1
High school	1
ICUR committee	1
Research supervisor/mentor	1

What were your greatest lessons or take-aways from the conference?

The following table summarizes categories mentioned in the open-ended responses to this question and the count of respondents who mentioned them. The summary is sorted by the greatest number of mentions to the lowest. 123 respondents answered this question; 30 mentioned more than one take-away. The sum of the category counts is 153.

A few criticisms were received in response to this question and are indicated in red text.

CATEGORIES OF COMMENTS	COUNT
Diversity of research	16
Learn about students'/others' research	14
Exposure to research conference experience	9
Graduate school info	9
Fourwaves poster session	8
Learn to communicate to a large audience/people outside my field	8
Gained confidence to present/conduct research	6
How to conduct research	6
Interacting with/meeting students	6
Opportunity to present/practice presenting my research/poster	6
Students' enthusiasm	6
How to be a better researcher/succeed with research	5
Value of research	5
Ability/potential/growth/empowerment of students	4
Meet the Prof session	4
Networking opportunities	4
Diversity of students doing research	3
Gained knowledge (not specified)	3
How to present research/posters	3
Closing session	2
Common challenges	2
Criticism: Not in person	2

Different paths to research/careers	2
Learn from industry professionals	2
Lightning talks	2
Ability to support students	1
Advice from faculty	1
Criticism: Desires only science/biology focus because it is difficult to present to people without a background on the topic	1
Criticism: Few or no attendees for student's individual poster	1
Criticism: No take-aways	1
Criticism: Poster presentation structure/platform	1
Criticism: Research is too political	1
Ethics of research	1
Feedback on my research	1
Funding opportunities	1
Imposter syndrome talk/issues	1
Interacting with/meeting faculty/professionals	1
Learn about fields and types of research	1
Praise: ICUR in general	1
Research is enjoyable	1
Students' positive response to ICUR experience	1
Diversity of research	16
Learn about students'/others' research	14
Exposure to research conference experience	9
Graduate school info	9
Fourwaves poster session	8
Learn to communicate to a large audience/people outside my field	8
Gained confidence to present/conduct research	6
How to conduct research	6
Interacting with/meeting students	6
Opportunity to present/practice presenting my research/poster	6
Students' enthusiasm	6
How to be a better researcher/succeed with research	5
Value of research	5
Ability/potential/growth/empowerment of students	4
Meet the Prof session	4

Strong responses:

- STUDENT: *"Attending ICUR enabled me to directly connect with students and faculty via discussions and LinkedIn. ICUR reinforced the fact that undergraduates are doing incredible things in Idaho and are solving problems!"*
- STUDENT: *"My biggest take-away is that I know what I am doing and I am chosen for the project for a reason. I should not let things like "Imposter Syndrome" get in the way because it only hinders what I am able to achieve."*
- STUDENT: *"Hearing from the Grad students was extremely useful and gave me concrete advice that I'm going to implement (and would not have known about had it not been for them!)"*

- STUDENT: *"I feel more confident as a researcher in my field. I know that there are many other people across many fields that are experiencing the same or similar struggles and victories."*
- STUDENT: *"I think I was exposed to how a conference works without the pressure of a national conference. It helped me dip my toes into research and conferences."*
- EDUCATOR: *"Listening to these students talk about their incredible research gives me such hope for the future. The students inspire me."*
- OTHER ROLE: *"It seemed like an excellent opportunity for the students to get used to presenting technical information. I sat in on my mentee's poster session and her comfort level increased significantly through repetition."*

What changes in the ICUR would significantly improve the conference experience for you?

The following table summarizes categories mentioned in the open-ended responses to this question and the count of respondents who mentioned them. The summary is sorted by the greatest number of mentions to the lowest. 103 respondents suggested a change; some made more than one suggestion. The total count of suggested changes/improvements is 129. 59 respondents either did not answer this question or indicated they had no suggestions for improvement.

CATEGORIES OF COMMENTS	COUNT
Conference - general	64
Poster sessions	38
Other logistics	12
Plenary/breakout/other talk sessions	12
SRC	2
Discipline focus	1
No changes suggested	59

Highlights:

- Conference - general
  - 46 people desire resuming an in-person conference and/or did not like the virtual format*
  - 3 people suggested better/more communication of sessions and details before conference begins*
  - 2 people gave session structure redesign suggestions*
  - 2 people think ICUR should increase its focus on students
- Poster sessions
  - 17 people said the poster sessions are not long enough*
  - 8 people said there were few or no attendees for a student's individual poster*
  - 3 people did not like the Fourwaves platform for the poster sessions*
- Plenary/breakout/other talk sessions
  - 3 people suggested better/more communication of sessions and details before conference begins*
  - 2 people made session structure redesign suggestions*
- Other logistics
  - 4 people did not like the Fourwaves platform*
  - 2 people said the registration process was confusing

**Repeat highlight from last year*

Changes/Comments by Category (sorted by the greatest number of mentions to the lowest):

CATEGORY > SPECIFICS	COUNT
Conference - general	***64***
Desires in-person / did not like virtual format	46
Positive comment / no changes suggested	4
Better/more communication of sessions and details before conference begins	3
Better/more networking opportunities	2
Session structure redesign suggestion	2
Increasing focus on students	2
Desires hybrid format	1
Not specified	1
Too political	1
Disorganized	1
Scheduling suggestion	1
Poster sessions	***38***
Not long enough	17
Few or no attendees for student's individual poster	8
Did not like Fourwaves	3
Desires in-person / did not like virtual format	2
Session structure redesign suggestion	2
Too long	2
Technological issue	1
Positive comment / no changes suggested	1
Boise State bias/focus/preference	1
Group by discipline	1
Plenary/breakout/other talk sessions	***12***
Better/more communication of sessions and details before conference begins	3
Session structure redesign suggestion	2
Positive comment / no changes suggested	1
Increasing focus on students	1
Too long	1
Less talk about mentoring	1
Too much focus on graduate school; not enough on other programs	1
Not long enough	1
Plenary/breakout/other talk sessions	1
Other logistics	***12***
Did not like Fourwaves	4
Registration process was confusing	2
Certificates	1
Other logistics	1
Schedule is confusing	1

Session structure redesign suggestion	1
Better communication during conference	1
Extended deadline for submitting posters and abstracts	1
SRC	***2***
Too long	1
Positive comment / no changes suggested	1
Discipline focus	***1***
More science content	1
No changes suggested	***59***

Project Title: Multiphysics Characterization of Printed Smart Materials and Systems

Project Period: 07/01/2021 – 06/30/2022

Reporting Period: 07/01/2021 – 06/30/2021

PI: Zhangxian (Dan) Deng

Institute: Department of Mechanical and Biomedical Engineering, Boise State University

1. Summary of project accomplishments for the period just completed and plans for the coming reporting period.

Global supply chain disruption and labor shortage caused by the COVID pandemic have significantly affected the project progress. The research lab for the proposed MTS load frame was flooded on May 23, 2022. This incident further disrupted the project schedule. To remedy the negative impact of logistics issues on Task 4 (magnetostrictive material characterization), the PI adjusted the budget to acquire another MTI fotonic probe that can work independently or along with the proposed frame. This probe is able to measure the magnetically-activated material deformation in sub-nanometer resolution. Achievements and future plans associated with each proposed task are presented in detail below.

Task 1: Acquire and install the MTS test system.

The proposed MTS load frame system was delivered on May 25, 2022. Load frame installation, on-site calibration, and user training were eventually completed on July 11-13, 2022. In addition, the new MTI fotonic probe system was delivered on May 14, 2022.

Task 2: Provide instrument training and increase visibility.

Students from the PI's lab were trained by MTS technicians on July 13, 2022. Training sessions were recorded and standard testing templates (e.g., tensile or cyclic testing) were prepared for future users.

Task 3: Characterize thermomechanical loops of printed shape memory polymers.

Achievements: Using a Geeetech A30M fused filament printer, the PI's lab has fabricated shape memory polymer (SMP) dogbone samples by mix printing polylactic acid (PLA) and thermoplastic polyurethane (TPU) filaments. The PI's lab has also customized SMP filaments by extruding PLA and TPU pellets in a 50:50 volume fraction. On a Hyrel Engine SR printer, the PI printed the first-ever morphing electrical circuit by innovatively merging direct ink writing and fused filament deposition. The PI's lab has completed the tensile testing of printed SMP dogbone samples at room temperature.

Collaborations: In collaboration with Dr. Brian Jaques from the Micron School of Materials Science and Engineering at Boise State University, the PI has preliminarily measured the thermomechanical loops of printed SMPs. The PI has identified the required force and temperature ranges for this type of tests. The PI has initiated collaboration with Dr. Harish

Subbaraman from the Department of Electrical and Computer Engineering at Boise State and completed dielectric constant measurement of the printed SMPs.

Publications: Adam Train, an undergraduate student from the PI's lab, published a paper entitled "All printed flexible and morphing electronics" in the conference proceeding of SPIE Smart Structures + Nondestructive Evaluation, 2022.

Plans after the Project Period: (a) Once the cooling water installation is completed in the PI's lab, the PI will continue characterizing SMP samples up to 80 Celsius. (b) The PI will publish their achievements on SMP-based morphing electronics on *Additive Manufacturing* in the next 6 months.

Task 4: Characterize the Young's modulus of magnetostrictive iron-gallium alloys.

Achievement: Since the domestic Galfenol provider (TdVib llc.) went out of business in Oct 2021, the PI selected magnetostrictive terbium-iron-dysprosium (Terfenol-D) for this task instead. The PI has printed the first-ever magnetostrictive composites using direct ink writing.

Collaborations: In collaboration with Dr. David Estrada at Boise State, the PI for the first time customized Terfenol-D nanoparticles using high energy ball milling. Together with Dr. Chien-hong Lin from National Cheng Kung University, Taiwan, the PI has developed a micromechanics model for Terfenol-D composites. Using the MTI fotonic system acquired in this project, the PI's lab collected a series of material property data for model validation.

Plans after the Project Period: (a) The PI will publish their recent achievements on Terfenol-D composite printing on *Additive Manufacturing*. (b) The PI has drafted a journal paper titled "Constitutive modeling of particulate magnetostrictive polymer composites" that is ready to be submitted to *Composite Structures*.

Task 5: Seek for long-term funding sources to support sustainable research and product commercialization.

Awarded Proposals: (a) In collaboration with researchers from NASA Ames, NASA MSFC, and NASA JSC, the PI was awarded a NASA EPSCoR proposal ($750,000 over 3 years) entitled "On-demand Manufacturing of Smart Systems for Structural Health Monitoring." In this project, the PI will use the MTS load frame to characterize the structural health monitoring capabilities of printed piezoelectric and magnetostrictive sensors. This project will also provide $60K funding to acquire a Correlated Solution digital image correlation (DIC) system that will be integrated with the MTS load frame to enable contactless strain measurements. (b) The PI received $1,800 from the CAES Senior Design Grant Program to purchase magnetostrictive iron-gallium alloys (Galfenol) samples.

Pending Proposals: (a) In collaboration with Dr. Joshua Daw from the High Temperature Test Laboratory at Idaho National Laboratory and Dr. Dylan Mikesell from the Department of Geosciences at Boise State University, the PI has submitted a proposal titled "Multiphysics mechanics of magnetostrictive materials" to NSF Program of Mechanics of Materials and Structures (MoMS). This proposal is currently under review. The PI plans to use the proposed

MTS load frame to characterize the temperature- and magnetic-dependent Young's modulus of Galfenol.

Declined Proposals: The PI submitted a proposal entitled "Guided Wave Ultrasonic Testing for Structural Health Monitoring in Extreme Environments" to Department of Energy. The PI plans to use the MTS load frame to characterize the printed magnetostrictive materials at elevated temperatures to verify their feasibility. This proposal passed the competitive pre-proposal phase but was declined in the full proposal review. The PI will work closely with researchers from Boise State and Idaho National Lab and target a resubmission next year.

2. Summary of budget expenditures for the period just completed

A total of $85,358.82 has been spent to purchase the MTS system. An additional $11,514.90 was used to acquired the MTI fotonic probe system. This results in a $3126.28 remaining budget. More details of the budget expenditures can be found in the spreadsheet included in this submission.

3. Numbers of faculty and student participation resulting from the funding

Faculty Participation (4): Zhangxian Deng, David Estrada, Brian Jaques, and Harish Subbaraman

Student Participation (6): Adam Tran, Braden Robinson, Drew Keller, Joy Morin, Amanda White, and Nick McKibben.

4. Patents, copyrights, and Plant Variety Protection Certificates received or pending

Nothing to report

5. Technology licenses signed and start-up businesses created

Nothing to report

6. Status of private part/industry partnerships

Nothing to report

7. Additional funding received and financial burn rate

Nothing to report

8. Any other pertinent information

Nothing to report

Idaho State University

Disaster Response Complex

College of Science and Engineering

Department of Civil and Environmental Engineering

IGEM20-001

A Disaster Response Complex for Emergency Responders in Idaho

3rd Year Final Report

July 1, 2021 – June 30, 2022

August 29, 2022

Table of Contents

1.0 Basic Project Information

Funding Agency

Higher Education Research Council - Idaho Global Entrepreneurial Mission Program

Awarded Institution

Idaho State University, College of Science and Engineering, Department of Civil and Environmental Engineering

Grant Number

IGEM20-001

Project Title

A Disaster Response Complex for Emergency Responders in Idaho

Principal Investigator

Mustafa Mashal, Ph.D., P.E., Associate Professor

Co-Principal Investigator

Bruce Savage, Ph.D., P.E., Professor and Department Chair

Report Type

3rd Year Final Report: July 1, 2021 – June 30, 2022

2.0 Executive Summary

In the post 9/11 years, the national demand for training of emergency responders from the military and law enforcement branches has grown rapidly. There is a higher demand for training of emergency responders than the current facilities can support. In 2019, researchers at Idaho State University were awarded funding from the State of Idaho under the HERC-IGEM Grant. The focus of the project is the development of a Disaster Response Complex (DRC) for research, certification, and training of emergency responders in collaboration with the Directorate of National & Homeland Security at the Idaho National Laboratory (INL), and the Center for Advanced Energy Studies (CAES). The DRC has three pillars: 1) research, 2) curriculum and certification, and 3) training. All three pillars include the development of new indoor and outdoor complexes with training lanes/simulations to be used in both research, teaching, and training of emergency responders and the instrumentation of a collapsed structure. The training lanes will be used in combination with Chemical, Biological, Radiological, Nuclear, and Explosive (CBRNE) surrogates/markers, the use of robots/small Unmanned Aerial Vehicle (sUAV), Virtual Reality (VR), Augmented Reality (AR), Geographic Information System (GIS), Light Detection and Ranging (LiDAR), and Radio-Frequency Identification (RFID). The curriculum pillar includes offering courses in topics such as emergency response, gamma/chem spectroscopy, and safety protocols. For the training pillar, the facility can be used to host events for clients such as the Department of Defense (DoD) CBRNE Response Enterprise (CRE), military personnel, Idaho National Guard, and law enforcement agencies/fire departments from Idaho and the region. It is expected that the DRC will be a comprehensive facility that will incorporate natural (earthquakes, hurricanes, flooding) and man-made hazards in the training of emergency responders.

3.0 Summary of Project Accomplishments (July 1, 2021 – June 30, 2022)

This is the progress report for the third and final year of the project. The third-year budget for the project is $283,100. Despite the ongoing global pandemic, the project personnel made substantial progress in the final year of the DRC as described below.

- From July 1st, 2021 to June 30th, 2022 more than 650 individuals excluding instructors and role players have participated in exercises and trainings offered through the DRC. The participants consisted of civil responders, community representatives, volunteers, county workers, and military personnel. Many of the participants were from the following entities: ISU EMT and other programs, ISU Public Safety, Healthcare professionals, Idaho State Police, Pocatello Police, Fire departments, Bomb squads, Bannock County Coroner's Office, and search and rescue units, Civil Support Teams from the National Guard representing multiples states, including Idaho and Oregon National Guard. More members of the National Guard from across the country are expected to train at the DRC in the fall of 2022. ISU DRC will be continuing its collaboration with INL and other partners on the training of the National Guard units. Numerous civilian responders are also expected to use the DRC for their training in the fall of 2022 and beyond.
- The DRC has been expanding its collaboration with local, regional, and national stakeholders. A Memorandum of Understanding (MoU) between ISU and Bannock County was explored to house the Regional "Emergency Operations Center" (EOC) inside the Armory building (indoor DRC) in Pocatello. The benefits for the Regional EOC in the indoor DRC (Armory building) were:
    - Centralized location
    - Consolidated resources dedicated to supporting all counties
    - Higher engagement and collaboration among counties
    - Dedicated normal operation area
    - Additional space readily available during activation

- Excellent collaboration and partnership opportunities with ISU and other stakeholders in the region

Through the EOC partnership, the DRC would have received funds (approximately $1.6M) from the American Rescue Plan Act of 2021 (ARPA) allocation of Bannock County. The funds were planned to be used towards the renovation of the Armory building (e.g. ADA compliance, utilities upgrade etc.). In late August 2022, ISU was notified that "Bannock County has elected to step away from the MOU and go in a different direction to utilize funding for a new county-owned facility that will best fit their needs." The collaboration between Bannock County Emergency Management and the DRC on the development of programs and the EOC are expected to continue.

- The EOC has the potential to expand and include seven counties in Southeast Idaho (Bannock, Bear Lake, Bingham, Caribou, Franklin, Oneida, Power) in the future. Many elected officials from Southeast Idaho, including the Bannock County Commissioners, have shown strong interest in collaborating with ISU and making the EOC a reality for the community of Southeast Idaho. The EOC will provide significant opportunities for everyone, including training, curriculum, and research opportunities for ISU students and researchers. The Director of the Idaho Office of Emergency Management (General Brad Richy) and some of his colleagues visited the Armory in the fall of 2021 to learn about the DRC and plans for the Regional EOC in Southeast Idaho. The basic operational structure of the Regional EOC is shown in Figure 1. The EOC will be a multidisciplinary unit with an assemblage of more than one function engaged in emergency management. The primary functions of the Regional EOC will be:
    - Collecting, analyzing, and sharing information
    - Supporting resource needs and requests, including allocation and tracking
    - Coordinating plans and deterring current and future needs
    - Providing coordination and policy direction

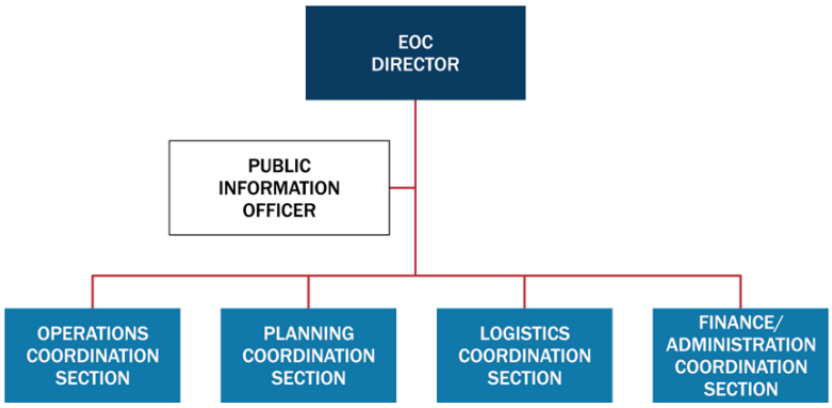


Figure 1. Structure of an EOC (after National Incident Management System, 3rd Ed., FEMA)

There will be three activation levels for the Regional EOC: Level 3: Normal Operation/Steady State; Level 2: Enhanced Steady-State/Partial Activation; and Level 1: Full Activation.

- The first annual Disaster Preparedness and Response Conference (DRPC 2022) was held at the DRC indoor facility (Armory Building) on April 8th and 9th, 2022. The conference hosted in excess of 100 participants for a two-day conference. The conference was very well received and tremendous support was shown for the continuation of the conference in future years. Appendix 4 presents surveys collected from the participants of this conference. The DRC is hoping to make this conference an annual event and partner with other interested entities for future events.

- Multiple tours of the DRC were held for the leadership from INL, CAES, Higher Education Research Council, Idaho Office of Emergency Management, Speaker of the House (Mr. Scott Bedke), legislators, elected officials, and others.
- Several tours of the DRC were provided for the stakeholders and potential partners on the project. There are ongoing discussions and collaboration between the DRC and private/public partners on new initiatives and programs. An example of such collaboration is the partnership between the DRC and the Qal-Tek Associates for offering a curriculum in disaster preparedness and response. Another example is the validation of instruments and equipment using the DRC collapsed structure (rubble pile), which took place in March of 2022.
- Additional research funds were obtained from ISU and CAES to engage more students and researchers on the DRC project. The DRC expanded its programs to include energy security, human-factors, biodefense collaboration, EOC collaboration, sensor data and other trending areas within INL and the Department of Energy.
- External proposals were submitted or are being developed to HERC-IGEM and NSF. More information is provided under the "Research" pillar.
- Students and researchers participated in scholarly activities in disaster response, such as submission of peer-reviewed journals, presentation of research in a national conference and at the DPRC 2022.
- A one-year marketing plan was developed for the DRC.
- A draft business plan for the long-term self-sustainment of the DRC was developed and shared with IGEM-HERC. The business plan is currently being finalized.
- Several media articles were published to promote and spread the word about the DRC and its potential as well as new focus areas such as energy security, sensor data etc.
- The DRC website (https://isu.edu/cee/research-facilities/drc/) was improved. New fliers, trifold, banners, and other marketing materials were developed to promote the DRC.
- The current HERC-IGEM funding concluded in June 2022. Given the potential benefit of the DRC to ISU and overall Idaho, the College of Science and Engineering at ISU provided support for a full-time employee (DRC manager) to continue the project beyond June 2022. Small support for the Director of the DRC and admin support were also provided.

A. Research Pillar

Efforts were primarily focused on research work and program development (whitepapers) in topics such as the use of robotics, Mixed Reality (Augmented Reality/Virtual Reality), electronic simulations of markers/surrogates for CBRNE training, public health, and disaster preparedness and response. Updates in each area of the research pillar are outlined as follows.

<u>Robotics:</u>

- An ISU doctorate candidate from Mechanical Engineering has been working on the robotic aspects of the DRC project in collaboration with ISU and INL researchers. The student has made good progress toward his dissertation focused on the use of robotics in disaster response. The student is expected to graduate in 2022.
- The DRC is collaborating with INL to investigate the use of mobile robots in infrastructure security and remote inspection tasks in Human-robot shared environments. The research is focused onthe advancing technologies of "dog" robots. CAES provided $50,000 for program development for the project titled "Mobile Robot for Security Applications in Remotely Operated Advanced Reactors." Refer to Appendix 1 for a news release on this project.

AR/VR:

- Six students (two doctoral, two masters, and two undergraduates) from various disciplines (Mechanical Engineering, Nuclear Engineering-Health Physics, Computer Science, Pharmacy, and Business Informatics) at ISU have worked under the supervision of the ISU/INL researchers on the AR/VR aspect of the project. The researchers from ISU and INL have been holding regular biweekly meetings to identify further research opportunities in this area. The AR/VR is an emerging area of research interest to many public and private institutions, especially during a pandemic when travel is limited. The project personnel held several demos for the use of AR/VR for the training of emergency responders.
- In 2022, CAES provided $50,000 for program development for a project titled "Investigation on designing a framework of utilizing sensor data in virtual training for disaster preparedness and response" which is led by INL researchers in collaboration with the DRC.
- In 2021, Dr. Mashal was awarded $20,000 for research in AR/VR through Idaho State University – Center for Advanced Energy Studies (ISU-CAES) funding. The project aims to develop AR/VR templates (e.g. exercises) for responders from both military and civil sectors. ISU is collaborating with researchers from INL on this project. The project was successfully completed. Two AR/VR templates have been developed. One template uses VR and focuses on the training of military responders in an immersive environment that simulates the aftermath of a Radiological Dispersible Device (RDD) (Figure 2). The other template uses AR and focuses on training of civil responders in a trench rescue scenario (Figure 3). The trench is currently under construction in the DRC.

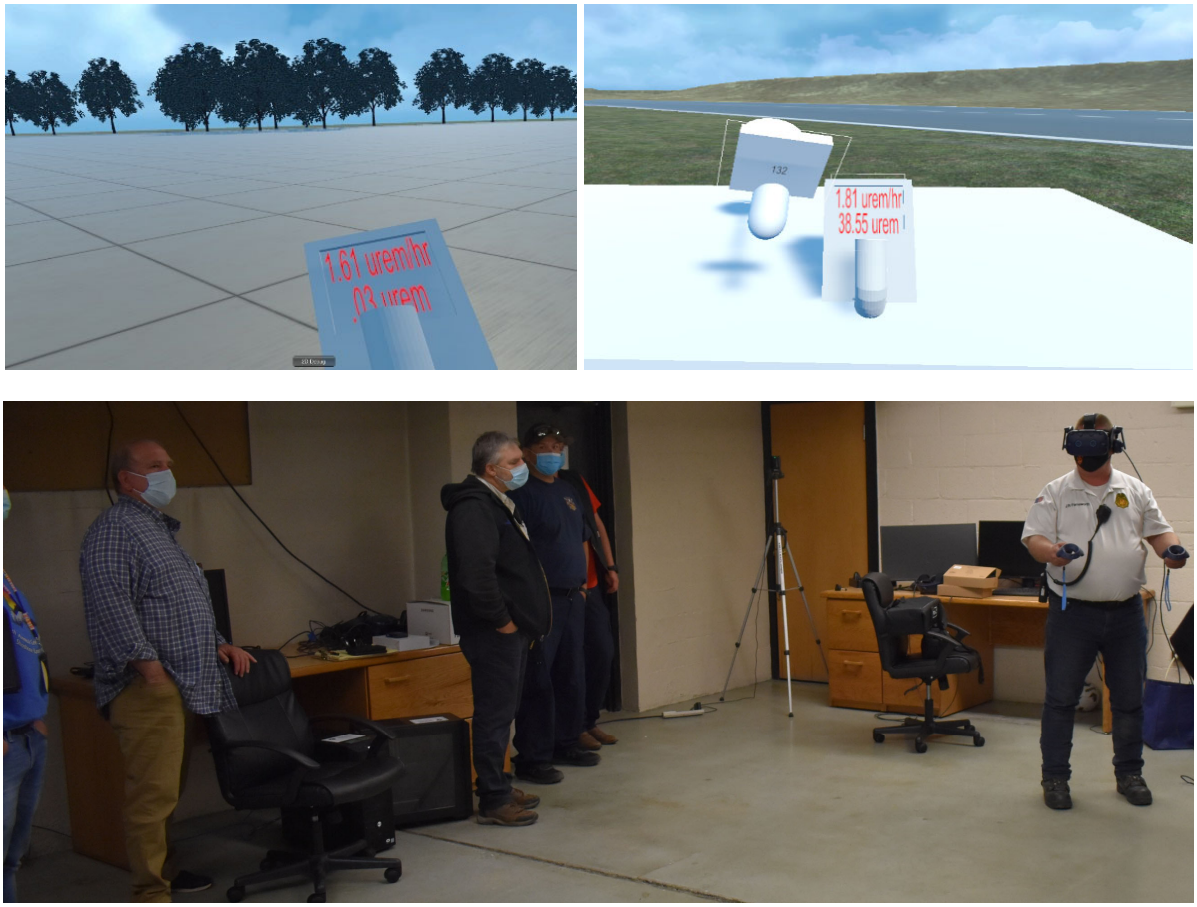


Figure 2. A volunteer responder is trying the VR set for a simulated RDD training in the GVL

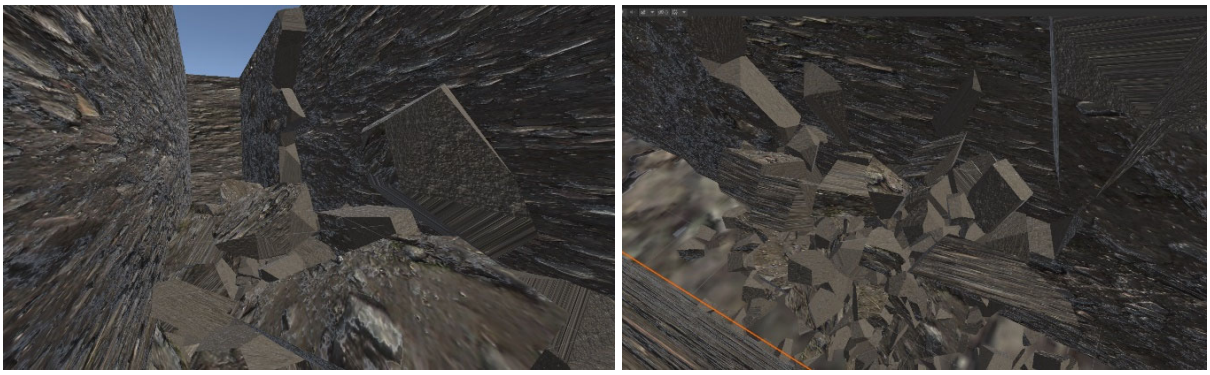


Figure 3. Shots of trench collapse template using AR

- New capabilities, space, and equipment were added in the new Gaming and Visualization Laboratory (GVL) which is located in the indoor DRC (Armory building). Several computers and AR/VR equipment were donated by a new faculty at ISU to upgrade the capabilities of the GVL. New students from Computer Science and Business Informatics have joined the GVL. A new "Gaming and Visualization" Club was also started to attract talents and create professional, training, social, and networking opportunities for ISU students. The DRC project principal investigator, Dr. Mashal, is the founding faculty advisor for the "Gaming and Visualization" Club at ISU.

Chemical, Biological, Radiological, Nuclear, and High Yield Explosives (CBRNE) Simulation:

- Further discussions and meetings were held between ISU and INL researchers to explore electronic simulations of CBRNE training.
- In May 2021, CAES funded $50,000 for program development for a Radiological Dispersal Device (RDD) Training using electronic simulations. The principal investigator from the ISU side is Dr. Mashal. All funding has been transferred to ISU. The majority of the funding is spent to support a graduate student from Nuclear Engineering-Health Physics at ISU on this project. The project has three phases. Phase I of the project was completed in September 2021. Phase II and Phase III are currently underway and will be completed by September 2022.
- CAES has also provided funding for biodefense collaboration as well as EOC collaboration between ISU and INL.

External Proposals:

- The project personnel submitted a proposal titled "A Disaster Response Complex for Emergency Responders" for $1,016,400 for three years (2022-2025) to HERC-IGEM. The proposal was not successful.
- The project PI (Dr. Mashal) led a team of researchers from three states (Idaho, Montana, and Wyoming) representing five universities (Idaho State University, Boise State University, University of Wyoming, Montana State University, and Montana Technological University) and Idaho National Laboratory, and submitted a concept paper titled "NSF Engines: Type 1: Resilient and Equitable Communities in the Northern Mountain West" for a competitive funding call from the National Science Foundation (NSF) Regional Innovation Engines Program. The concept paper was accepted and the team is planning to submit a full proposal in September 2022. The NSF Engines program provides up to ten years of funding per Engine award with a maximum budget of $160 million, with the opportunity to receive up to two years of funding ($1 million) to support

development activities prior to NSF Engine creation. The DRC is one of the main focuses in the ISU's proposal to NSF.

- The project personnel are considering pursuing a funding opportunity titled "Building Resilient Infrastructure and Communities" (BRIC) from the Department of Homeland Security.

Scholarly Activities:

- A journal paper titled "Virtual and Augmented Reality in the Disaster Management Technology: A Literature Review of the Past 11 years" was published in the Frontiers of Virtual Reality journal.
- A journal paper titled "Should We Offer Disaster Preparedness and Response Training Workshops Across Idaho? A Feasibility Study" was published in the Journal of Emergency Management.
- A journal paper titled "A Disaster Response Complex for Training of First Responders in Idaho" was revised and submitted for publication in the Journal of Emergency Management. The paper is currently being peer-reviewed.
- An ISU graduate student presented a 35-minute presentation on "Virtual Reality and Augmented Reality as Novel Tools for Training of Emergency Responders" during the 6th Annual International Conference of the Campus Alliance for Advanced Visualization (CAAV 2021) hosted by Purdue University on November 1-4, 2021 (virtual presentation).
- An ISU graduate student presented a 30-minute presentation on "RDD Training Utilizing VR and Live Training" during the 6th Annual International Conference of the Campus Alliance for Advanced Visualization (CAAV 2021) hosted by Purdue University, November 1-4, 2021 (virtual presentation).
- Five ISU students working on the project presented their work through a poster presentation at the 2022 Disaster Preparedness and Response Conference (DPRC) in Pocatello. These posters were:
    - K. Hogarth, M. Mashal, and J. Cantrell. "A Disaster Response Complex (DRC) for Research, Curriculum, and Training of First Responders."
    - M. Iqbal, M. Mashal, M. Khan, J. Grider, R. Squires, R. Richardson, J. Koudelka, A. Thornley and I. van Woerden. "Should We Offer Disaster Preparedness and Response Training Workshops Across Idaho? A Feasibility Study."
    - U. S. Medasetti, J. Dunker, Z. Free, S. Banda, and M. Mashal. "Disaster Response in VR."
    - U. S. Medasetti, A. Sebastian, and M. Mashal. "Scaled Source Recovery in Mobile Hot Cell Using UR5e."
    - J. Dunker, M. Mashal, and B. Marsh. "Radiation Dispersal Device Response Training."
- Dr. Mashal Presented a lightning talk at the INL Collaboration with NUC and CAES titled "Disaster Response, High-Performance Concrete, Hydrogen Storage, Industry 4.0: Where Civil Engineering Crosses Other Disciplines" on July 28, 2021.
- Dr. Mashal was invited by INL to present a webinar on the Disaster Response Complex for the INL Resilience Optimization Center on July 14, 2021.
- Dr. Mashal and Bryon Marsh from INL presented a talk on the DRC collaboration at the CAES Codebreaker Series to researchers from INL and CAES consortium on May 5, 2022.
- A master's student from the Department of Civil and Environmental Engineering at ISU successfully completed and defended his Master's Special Project titled "Design and Construction of a Disaster Response Complex in Idaho for Training of Emergency Responders."

- A master's student from the Department of Nuclear Engineering-Health Physics at ISU has been working toward his thesis on the electronic simulation of HazMat in disaster training.
- A PhD student from the Department of Mechanical Engineering has been writing his dissertation on the use of robotics in disaster response.
- The DRC collaborated with ISU's Department of Community and Public Health, ISU's Continuing Education Workforce Training, INL, CAES, Qal Tek Associates LLC and other partners from the public and private industry, to host a two-day conference titled "Disaster Preparedness and Response Conference" in the indoor DRC on April 8th and 9th, 2022 (Figure 4). The Conference drew more than 100 participants. President Satterlee of Idaho State University delivered the opening remarks for the conference.
- The Conference themes focused on: 1) innovative technologies in disaster response and preparedness; 2) public health. The attending participants consisted of researchers/students; fire department; law enforcement; military; healthcare professionals; non-profit search and rescue; and other responders. The participants received Continuing Education Units (CEUs) for attending the conference. A few highlights of the conference included the following sessions:
    - Keynote Speaker: Laurie Holien, Idaho State University, Homeland Security and Emergency Management Director
    - Guest Speakers: the conference hosted managers, leadership, and world-class researchers from several governmental agencies (e.g. military, Bureau of Emergency Medical Services and Preparedness) within the State of Idaho to be speakers and panelists
    - Invitation to attend the conference was extended to everyone at INL, CAES Universities, and some nearby universities in Utah
    - Parallel sessions on different topics (e.g. Introduction to Disaster and Management Cycle; Disasters and Response/Recovery at the US level; Differences in Community Vulnerability and Resilience; Transportation; Military Support; Infectious and Emerging/Reemerging Diseases; Communication/Evacuation Plan; Mitigation/Recovery; Emergency/Pandemic Preparedness; Emergency Preparedness Kits; Networking)
    - Student and Researcher poster session
    - Hands-on activities and demonstrations by Qal-Tek Associates, Pocatello Fire Department, Applied Visualization Laboratory at CAES, Southeast Idaho Public Health, and others
    - Exhibition Hall
    - An Award session for best posters (students/other researchers)
    - The conference received sponsorships and exhibition fees from many different entities which helped to keep the conference registration cost very affordable to everyone
- Discussions, meetings, and tours of the DRC were held to explore and build research collaboration with INL, CAES, ISU, law enforcement, office of emergency management, Southeast Idaho Public Health (SIPH), local fire departments, and private companies.
- The project personnel reached out to several researchers and faculty at ISU from different units, inviting them to explore collaboration on research and curriculum with the DRC.
- Tours of the DRC were held for dignitaries from CAES, INL, ISU, Idaho State Board of Education, and the Idaho Speaker of the House, Mr.Scott Bedke (Figure 5).
- Invitations to tour the DRC has been extended to Members of Congress representing Idaho.

Figure 4. DPRC 2022, DRC Armory April 8-9,2022

Figure 5. Idaho Speaker of the House Mr. Scott Bedke touring the DRC Armory

B. Curriculum and Certification Pillar

- The DRC has partnered with Qal-Tek Associates in Idaho Falls to offer an emergency response curriculum. Seven courses in various topics (e.g. HazMat, confined space rescue technician, etc.) have been selected for offering through the DRC in the fall 2022. The courses are offered for a fee to the participants. The DRC is working with the Continuing Education Workforce Training at ISU for the advertisement and registration for these courses.
- The DRC, in collaboration with INL, CAES, SIPH, local fire departments, local medical doctors, healthcare professionals, ISU's Continuing Education Workforce Training, and ISU's Department of Public Health, hosted a one-day seminar on "Acute Disaster Response Training" on August 24, 2021 (Figure 6). The seminar was free for the participants (Appendix 1). Based on the participant

feedback, the seminar was a success. The curriculum for the seminar was prepared by researchers and healthcare professionals. The curriculum is expected to be utilized for the follow-up training and educational events through the DRC.

- The project personnel have had discussions and tours of the outdoor DRC with potential instructors/partners from local fire departments and the private industry to develop a curriculum for emergency responders in the military, law enforcement, emergency management, and fire departments.

Figure 6. Acute Disaster Response Training in the indoor DRC

C. Training and Exercise Pillar

In the final year, the project personnel were able to continue training at the DRC while it has continued to add additional training lanes and improvements. More than 650 individuals excluding instructors and role players have participated in exercises and trainings offered through the DRC since July 1st, 2021. Of these individuals, about 420 were civilian responders and the rest were military responders, primarily Civil Support Teams from the National Guard representing multiple states.

- Between July 1st – December 31st, 2021, 13 training events were held for the Civil Support Teams from the National Guard and civilian responders. The majority of these training events were conducted in the indoor DRC (Armory building) in collaboration with INL. Some of the training events were highlighted by media outlets (Appendix 1).

Sample Training Events:

- In August 2021, 35 individuals participated in a two-day training event. This was organized by the Idaho Regional HazMat Response Team Exercise through Radiological Assistance Program (RAP) (Figure 7 The training included demos by the private industry (e.g. Qal-Tek Associates and other vendors).

Figure 7. Training by the Pocatello Fire Department's Urban Search and Rescue team

- In September 2021, 25 members of the Idaho and Oregon National Guard Civil Support Teams conducted a simulated Radiological Dispersal Device Exercise (Figure 8). This training was in collaboration with National and Homeland Security at INL. The event marked the return of the Idaho National Guard to the Armory building after more than 50 years. The event brought in much sense of pride and excitement to ISU and the community. ISU and INL are working on a media article about the history of the Armory building. Students at ISU conducted interviews with

members of the community who remembered the Armory building to gather stories for this article. The students were also able to find documents and other information regarding the building when the National Guard was stationed there between 1939 to 1960s. The article is expected to be published in early 2022.

- Every November and April the ISU Emergency Medical Technician (EMT) Program conducts a workshop at the DRC. This exercise serves at the EMT's mass casualty capstone workshop and takes place every fall and spring. The DRC has been able to host the course for 3 years running, with plans to continue the collaboration. A typical workshop is held for 15 to 30 students along with 6 instructors and various numbers of roll players. The exercises have included the participation of the local hospitals and fire departments (Figure 9).
- In November 2021, there was a "Death Investigator Course" presented through Bannock County Coroner's Office in the DRC.
- In July 2021, the Local Emergency Planning Committee (LEPC) for Pocatello had their kickoff meeting in the indoor DRC (Figure 10). There were 42 participants from the businesses and public entities in Southeast Idaho.
- Starting in April of 2022 the DRC hosted Incident Command System 300 and 400 courses as a part of the upcoming Regional EOC efforts between ISU DRC and Bannock County.
- In May of 2022 the DRC hosted a Regions CISM Training and Support course which had 77 participants for a 3-day course.
- In June of 2022 the DRC hosted the 101st Weapons of Mass Destruction Civil Support Team at the DRC outdoor facility for an exercise (Figure 11).

Figure 8. Members of the Idaho and Oregon National Guard training in the indoor DRC

Figure 9. EMT Workshop simulating a mass casualty event in the indoor DRC

Figure 10. LEPC meeting in the indoor DRC

Figure 11. 101st Weapons of Mass Destruction Civil Support exercise outdoor DRC

- Other updates from the third year of the project includes, but not limited to:
    - Design and construction of new training lanes at outdoor and indoor facility (Figure 12).
    - Improved the indoor DRC (Armory building), set up new research space, classrooms, meeting rooms, building signs etc. Purchased furniture, desks, educational equipment and accessories (e.g. projector screens).
    - Development of a draft business plan for the long-term sustainability of the DRC.
    - Development of a one-year marketing plan for the DRC.
    - Development of marketing details, including trifolds, brochures, banners, websites etc. for the DRC.

Figure 12. Simulated Subway Car training lane located in DRC Armory Basement

4.0 Plans for the Upcoming Reporting Period

Not applicable. The project ended on June 30, 2022 and this is the last year final report. ISU has plans and initiatives to support the DRC and make it sustainable in the upcoming years.

5.0 Expenditure Report

The project expenditure until December 2021 is presented in Table 1. The project exhausted $270,631.10 for the third year. A breakdown of the budget and expenditure report is provided in Appendix 3.

Table 1. Summary of Budget Expenditures

Salaries & Fringes (faculty, personnel, student employees, research engineer/lab manager)	$197,208.30
Travel	$0
Capital Expense	$31,820.57
Services and Supplies	$41,602.23
Total	**$270,631.10**

6.0 Partnerships

Since 2019, the project personnel have had discussions with the interested individuals and entities listed in Table 2 on this project with one or more pillars of the DRC project. The impact of the partnership with some of the entities named in Table 2 has created opportunities for students and faculty at ISU as well as the collaborators.

A full-time Research Engineer/Lab Manager position was created for this project. The position was filled and the Research Engineer/Lab Manager started on November 4, 2019. The Research Engineer/Manager helps with all three pillars of the DRC project, including business plan, marketing, design/construction of training lanes, and supervision of several students working on the DRC project.

Table 2. Entities that have toured/visited/briefed/or collaborated on the DRC project

No	Entity Name
1	Idaho National Laboratory • National and Homeland Security Directorate • Energy and Environment Science and Technology • Nuclear Science and Technology
2	The Center for Advanced Energy Studies
3	Department of Energy • Idaho Operations Office
4	Idaho Department of Environmental Quality • INL Oversight Program
5	Idaho Office of Emergency Management • Southeast Idaho • East Idaho • Boise Area
6	Idaho National Guard • Homeland Response Force • Civil Support Team
7	Idaho Falls Fire Department

8	Pocatello Fire Department
9	Pocatello Police Department
10	Idaho State Police
11	Qal-Tek Associates, LLC
12	Technical Resources Group, Inc.
13	Snake River Search and Rescue, Inc.
14	Argon Electronics
15	Preparedness Innovations
16	Eastern Idaho Fire Chiefs Association
17	Eastern Idaho Safety Consultants
18	Bannock County Emergency Services
20	Caribou County Public Safety and LEPC
21	Idaho State University • College of Technology - Nuclear Operations Technology - Continuing Education/Workforce Training) • Kasiska Division of Health Sciences - Institute of Emergency Management - Emergency Services Department - Department of Community and Public Health • College of Science and Engineering - Department of Mechanical Engineering - Department of Computer Science - Health Physics - Physics - Department of Chemistry - Electrical and Computer Engineering - Environmental Monitoring Laboratory • College of Arts and Letters - Department of Political Science • Department of Public Safety • Emergency Management • GIS Center • Idaho Accelerator Center

7.0 Economic Impact

Excluding the research and curriculum pillars, and considering only the training & exercise pillar for the DRC, as of June 2022, more than 1,000 individuals from across the United States have used the DRC for the world-class and unique training. If a regional multiplier[1] model is used to measure the economic impact, and a conservative estimate of $500 per participant who trained at the DRC is used, the regional multipliers

[1]A multiplier model uses an approach to measure how important one industry is to other industries in the region. For instance, a multiplier of 1.5 means that for every dollar spent on that industry, the regional economy will be affected by 1.5 times the original investment.

for Southeastern Idaho based on Idaho's Department of Labor's most recent data from June 2021 for "Professional and Management Development Training" would be as follows:

- Sales Multiplier = 1.48
- Jobs Multiplier = 1.12
- Earnings Multiplier = 1.31
- Regional Economy Impact (Sales) = 1,000 x $500 x 1.48 = $740,000
- Regional Economy Impact (Jobs) = 1,000 x $500 x 1.12 = $560,000
- Regional Economy Impact (Earnings) = 1,000 x $500 x 1.31 = $655,000
- Total Economy Impact (Sales + Jobs + Earnings) = $1,955,000

In summary, it is estimated that the total economy impact of the DRC by the end of the project (June 30, 2022) was almost twice of the total original funding received from HERC-IGEM in 2019 ($1,083,600).

8.0 Faculty and Student Participation

Through June 30, 2022, the numbers of faculty, students, and other researchers who participated in one or more areas on the DRC project at ISU are listed in Table 3. Appendix 2 provides sample student activities for some of the students working on the project.

Table 3. Participating Researchers

Position	**Numbers**
Faculty	9 (including the PIs)
Graduate Students	9
Undergraduate Students	15
Researchers	6
Total	**39**

9.0 Metrics for Establishing Project Success

Table 4 presents a summary of the metrics for establishing project success. Despite the challenges imposed by the global pandemic, the project made good progress toward the original metrics and mostly achieved its goals.

Table 4. Summary of the Criteria for Measuring Success for Year 3

Criteria	Pillars of the Disaster Response Complex		
	Research	Curriculum & Certification	Training & Exercise
Original Proposal	1. Publication of 3-4 papers. 2. Presenting research findings in a national conference. 3. Hiring two additional graduate students (MS or PhD level). 4. Hiring a permanent receptionist and coordinator. 5. Hiring 1-2 new research/teaching faculty.	1. Development of two additional classes in emergency training in collaboration with INL/CAES. 2. Providing certification to first responders. 3. Offering training courses to 150 students/first responders.	1. Training of 800 responders. 2. Expanded local fire departments and emergency response customers, all hazards including natural disasters.
Actual Performance	1 & 2. The project personnel published several papers and presented in multiple conference. 3. Additional graduate students were hired to assist with different aspects of the project. 4. Due to budget constraints, part-time student employees were utilized to help with administrative and logistical items for the project. 5. This did not happen due to budget constraints.	1. The DRC partnered with Qal Tek and others and developed/advertised more than two classes. 2 &3. The DRC provided CEU's to more than 100 participants from across the emergency responders community who attended the 2022 DPRC in Pocatello.	1. More than 650 responders were trained. Additional training events was hosted beyond June 30, 2022. 2. Progress was made towards housing a Regional EOC in the DRC. In late August 2022, ISU was notified that the County elected to go in a different direction for the physical location of the EOC. The DRC and the County are expected to continue their on-going collaboration on the EOC and other initiatives.

10.0 Future Plans

Multiple training and exercise events at the DRC were hosted in 2022. In addition, work is on-going to offer several courses in collaboration with Qal-Tek Associates and develop new curriculum with INL and other collaborators. There is on-going research in the use of AR/VR, Robotics, Public Health, and other areas. The DRC hosted the "Disaster Preparedness and Response Conference" in the spring of 2022. The conference was the first of its kind in Southeast Idaho and attracted more than 100 participants with world-class and national/state expert speakers.

One of the milestones for the third year of the project was to work with the elected officials in the region to host the Regional EOC in the indoor DRC. ISU and Bannock County were in the final stages of signing an MoU for the Regional EOC. Bannock County was considering using approximately $1.6M from its American Rescue Plan Act of 2021 (ARPA) allocation to renovate the indoor DRC (e.g. add ADA compliance). However, in late August 2022, ISU was notified that the County has decided to step away from the MoU and go in a different direction for the physical location of the EOC that fits their needs better.

The intent of the DRC was originally to be a self-sustaining entity by the end of three years of funding. However, the pandemic has placed severe limitations on hosting training events in Pocatello and at ISU between February 2020 – May 2021. Several planned training events for 2020 had to be canceled. Additionally, the sizable demand for an indoor training space was unexpected. While the project personnel have responded to the identified changing market demands, in reality, the Armory building has been functional for less than one and half years. ISU leadership has shown strong support for the DRC and has

been working with the project personnel to finalize a business plan for the long-term sustainment of the DRC.

Future improvements and renovations of the Armory building such as: adding ADA compliance, renovating the building and its utilities, introducing new training lanes in the indoor/outdoor facility, partnerships with the private and public industry, hiring new researchers and students to work on different pillars of the project, training more emergency responders, arranging tours for potential partners and stakeholders, and spreading the word about the DRC in Idaho and the Pacific Northwest. Funding opportunities such as the NSF Engine Type I and BRIC are actively being pursued/considered to further develop the facilities for project continuation and expansion. In addition, there are several on-going collaborations funded by CAES for the DRC in 2022-23.

11.0 Commercialization Revenue

The project principal investigator (Dr. Mashal) was notified on November 23, 2021 that the US Patent Application Entitled: “Ductile Connections for Pre-Formed Construction Elements”, Application No.: 16/817,042, will be issued by the U.S. Patent and Trademark Office in early 2022. The patent is not directly connected to the DRC project; however, it aims to reduce and eliminate earthquake damage in concrete structures and make the built environment resilient to disasters such as earthquakes. The patent was issued in March 2022 and the inventor is planning to commercialize it in North America.

Appendix 1. Sample Media Articles

Disaster Response Complex to Host Acute Disaster Response Training Workshop Aug. 24

August 19, 2021

The Disaster Response Complex in the Department of Civil and Environmental Engineering in the College of Science and Engineering, in collaboration with the Department of Community and Public Health in the College of Health, and the ISU Continuing Education and Workforce Training, is offering a one-day training workshop Aug. 24 to prepare ISU students and interested health care professionals to respond in an acute disaster setting.

Speakers from Southeastern Idaho Public Health will train the participants to develop resilience to disasters before they strike and identify the communication needs and challenges during a disaster. Other presenters include expert local physicians who will also train participants to perform triage on the scene and provide field care and casualty management, also focusing on the prevention and management of infectious disease outbreaks amidst disasters.

Researchers from the Idaho National Laboratory will also be presenting and demonstrating augmented reality/ virtual reality for disaster response as an emerging technology for training emergency responders when travel is restricted such as during a pandemic.

Article Link: https://www.isu.edu/news/2021-fall/disaster-response-complex-to-host-acute-disaster-response-training-workshop-aug-24.html

ISU, INL host disaster response training for Oregon, Idaho National Guard

Kalama Hines, EastIdahoNews.com

Local Published at 2:16 pm, September 30, 2021 | Updated at 4:36 pm, September 30, 2021

Members of the National Guard Civil Support Teams (CST) train in responding to an apparent explosion involving radiation exposure during an exercise at the Idaho State University Disaster Response Complex on Wednesday, Sept. 29, 2021. This training program will continue all week, including some exercises at Idaho National Laboratory. | Kalama Hines, EastIdahoNews.com

POCATELLO — More than a dozen men and women dressed in radiation suits converged on a building that, until 2020, had been a warehouse serving the Idaho State University diesel tech program.

Those men and women, representing the Idaho and Oregon National Guard Civil Support Teams (CST), underwent disaster response training Wednesday afternoon at ISU's Disaster Response Complex.

The training put the teams through different mass-casualty scenarios, including what Mustafa Mashal called a "dirty bomb" response.

Mashal, an associate professor in ISU's civil and environmental engineering department, said CST teams are trained to respond to all types of manmade and natural disasters, to "control the situation and, at the same time, provide the assistance to civilians."

"Their mission is to save life and property during events that can affect many people," Mashal told EastIdahoNews.com.

CST team members scan a bus for radiation levels using a Geiger counter. | Kalama Hines, EastIdahoNews.com

CST team members scan a mannequin for potential radiation exposure using a Geiger counter. | Kalama Hines, EastIdahoNews.com

This particular training exercise is part of a week-long training program led by the Idaho National Laboratory Homeland Security group. Similar training exercises are run through INL 15 to 20 times per year, according to INL spokeswoman Michelle Farrell.

“We have a program that works with the National Guard Bureau CST teams,” she said. “We run them through this training throughout the year.”

The training is standard. What is unique is the site.

According to Mashal, the Idaho National Guard has not conducted a similar training exercise on the ISU campus in over 50 years.

An intentionally damaged bus and a mannequin, prepared for one of Wednesday's training exercises. | Kalama Hines, EastIdahoNews.com

The building, now serving as the university's Disaster Response Complex, was originally constructed in 1939, Mashal explained, with the purpose of serving the National Guard in mind. But in 1970, the facility was taken over for diesel tech classes.

Then, in 2020, it was vacated. The civil engineering department was prepared for the change and has spent the last four years developing a training facility that will bring events like Wednesday's back to the campus.

Katie Hogarth, a graduate student in civil engineering department, has been part of that entire process.

"We first came up with the idea with INL and in 2017 we started developing concepts," she told EastIdahoNews.com.

Members of the CST team continue to check a mannequin while other remove their radiation suits. | Kalama Hines, EastIdahoNews.com

Standing in the facility, watching trainers and trainees work through different scenarios, Hogarth was proud of the work she and her colleagues have completed. But she was also excited about the opportunity.

Earlier this week, she said, she met a woman who assisted in the response to massive floods in the 1960s. The woman told Hogarth that members of the National Guard and area first responders sandbagged the city while working out of the same building that now houses the Disaster Response Complex.

The complex is more than 25,000-square feet, around 75 yards long and wide enough to mimic a two-lane road with space on either side.

“We can constantly change (the layout) to do different scenarios and different mock situations, and train different levels of emergency response,” said Jared Cantrell, ISU Disaster Response Complex Project Manager.

The simulated city block includes false storefronts and, for Wednesday’s training, a bus damaged — in a controlled environment — to mimic an explosion.

CST team members transport the mannequin from location of the incident to their safe zone. | Kalama Hines, EastIdahoNews.com

Both Mashal and Cantrell are hopeful that the complex will see constant training exercises similar to Wednesday’s. Both brought up the facility’s usefulness as it pertains to training programs for police and fire units.

“We’re very blessed to see today, the U.S. flag is hanging again (in here) and the National Guard utilizing the facility,” Mashal said.

The inside of the ISU Disaster Response Complex. | Kalama Hines, EastIdahoNews.com

Article Link = https://www.eastidahonews.com/2021/09/isu-inl-host-disaster-response-training-for-oregon-idaho-national-guard/

ISU host disaster training

September 29, 2021 6:31 PM

POCATELLO, Idaho (KIFI) - Idaho State University partnered with the Idaho National Laboratory to host a joint training exercise between the Idaho 101st and Oregon 102nd Civil Support Teams.

The collaborative training prepares local first responders for major events and disasters with realistic scenarios.

"The scenario is to replicate a terrorist incident where a device was detonated on the bus creating casualties and causing radiological contamination," said INL Program Manager Bryon Marsh.

Medical Operations Officer Erica Bermensolo says the simulation training has been a real lesson on saving lives.

"I don't get a lot of experience with radiological exposures and to do it in a simulated environment has really broadened my knowledge," Bermensolo said.

It's training that Bermensolo values greatly.

"For us being five or so hours away, I mean that's not something we can get every day," Bermensolo said. "We can simulate it, but to be here and having professional train us. I just think is immeasurable."

The training took place at ISU's Disaster Response Complex

Article link = https://localnews8.com/news/2021/09/29/isu-hosts-disaster-training/

Link for Another Article about the training on Idaho State Journal = https://www.idahostatejournal.com/news/local/isu-hosts-disaster-response-training-exercise-in-repurposed-facility/article_f98d41ec-09cc-514d-873a-17ad35cf8dce.html

Idaho State, INL Host Disaster Response Training

October 4, 2021

Idaho State University and the Idaho National Laboratory are working together to make sure disaster relief teams are prepared for anything that comes their way.

On Wednesday, teams from the Idaho National Guard's 101st and Oregon National Guard's 102nd Civil Support teams worked together on a practice scenario simulating the aftermath of a bomb explosion on a bus on a busy street.

The teams used radiation detectors and protective gear, and practiced extricating and providing treatment to trapped life-like dummies, or "passengers."

The training was one of many that Idaho State has hosted at its Disaster Response Complex. The complex has room for both indoor and outdoor scenarios. At its outdoor location, teams can practice on scenarios such as earthquakes, rubble pile rescues and more. Indoor trainings, such as Wednesdays, are hosted at the Armory Building on South Second Avenue. There, they can simulate manmade and indoor disasters.

Since opening in 2020, the Complex has hosted hundreds of first responders, who previously had to travel from as far away as Texas, said Director Mustafa Mashal.

"We saw a gap and we wanted to fill it and make sure that we have a long-term asset for our community of first responders in this part of the country," he said.

Article Link = https://www.isu.edu/news/2021-fall/idaho-state-inl-host-disaster-response-training.html

CAES-Funded Project Aims to Help Modernize, Optimize Physical Security at Nuclear Power Plants

Physical security at nuclear power plants has traditionally been heavily labor-intensive, requiring multiple shifts of staff per day. A team of researchers from Idaho National Laboratory (INL) and Idaho State University (ISU) is examining the feasibility of using robots to enhance and modernize security operations at these plants.

The project, one of 13 to receive CAES Collaboration Funds this year, aims to develop a "research roadmap" on the use of robots for security purposes at nuclear power plants. The project is led by Vaibhav Yadav, an instrument controls and data science researcher with INL's Nuclear Science & Technology Directorate, and ISU's Mustafa Mashal, a CAES Fellow and associate professor in the Department of Civil and Environmental Engineering, with assistance from Uma Shankar Medasetti, a PhD student at ISU.

The team plans to publish a paper on the topic, exploring issues such as the technical feasibility of using robots to conduct security operations – how do they perform in adverse weather conditions, for example, and what are the limitations associated with performance characteristics such as battery life. An important question being considered is: How can a currently operating plant or a future reactor site demonstrate that it meets the performance and regulatory requirements of physical security in using a fleet of four-legged robots? The first step of the team's research is to gain an understanding of the technology utilized by robot manufacturers and how that technology impacts performance. To accomplish this, they are conducting comparative analysis of the different robot offerings and have engaged with several robot vendors as part of this effort.

"We're wrapping up our review soon and will get a preliminary paper out," Yadav said, adding that "the goal is to create a research roadmap" that will pave the way for future research in use of dog robots for security applications such as intrusion detection, patrolling, inspection and communication, as well as other nuclear applications including industrial inspection, maintenance and radiation measurements. Eventually, the research team plans to utilize ISU's Disaster Response Complex for conducting experiments in assessment of performance effectiveness of the robots. The outdoor DRC site spans approximately three acres on ISU's business park in Pocatello. It accommodates research, curriculum development and training/exercises for emergency responders from across the region. CAES provided seed funding for the DRC project, which involves INL and dates to 2018, when its director, Mashal, met INL researcher Bryon Marsh at the CAES Security Collaborative Research Planning Meeting. Later that year, the project received CAES Collaboration Funds. In 2019, Idaho's Higher Education Research Council awarded the project nearly $1.1 million through the Idaho Global Entrepreneurial Mission initiative. CAES Collaboration Funds are awarded to projects led by INL researchers in partnership with faculty members/researchers from the CAES universities. The goal is to establish and foster relationships between the CAES entities in research, education and innovation. Details can be found here.

Idaho State University PhD student Uma Shankar Medasetti (left) and Idaho National Laboratory researcher Vaibhav Yadav pose with robots during a recent demonstration by a robot vendor at INL. Yadav and Medasetti are working on a CAES-funded project studying the ways in which robots can help optimize and modernize physical security operations at nuclear power plants.

Article Link = https://caes.org/caes-funded-project-aims-to-help-modernize-optimize-physical-security-at-nuclear-power-plants/

Appendix 2: Sample Student Activities

Dates	Uma Shankar Medasetti	Sindi Banda	Jack Dunker	Zack Free
6/28/2021	Attended Meeting with Logan and INL folks about the project		Refactored dose rate code. Implemented placeholder model for dose rate meter. Attended INL RDD survey training. Attended DRC meeting and presented WIP of VR system. Implemented locomotion in VR	
7/5/2021			Setup Virtual reality control scheme allowing for objects to be physically carried. Investigated tools to reduce motion sickness in VR. Researched implementation of necassary AR software and toolkits	
7/12/2021			Finalized implemenation of VR controller. Began setup of second training scenario/VR orientation area. Attended DRC seminar and bi-weekly meeting. Met with INL to demo VR project.	
7/19/2021	Worked with Ellen to get property tag for Microsoft Hololens		Met with John Koudelka and INL VR team. Researched continuous redirected movement for VR. Updated VR landscape with higher resolution textures and more environment detail. Refactored shielding calculation in radiation simulation	
7/26/2021	fininished working on additional papers for the Journal.		Met with DRC visualization team to discuss weekly plans. Met with CAES visualization team. Updated movement system to make smooth accelerated movement. Helped implement teleportation movement	
8/2/2021	We went to Merdiain to bring the equipment		Met with CAES visualization team. Stayed on to assist/spectate blender tutorial. AR/VR weekly meeting	
8/9/2021	Sent the desktops to COSE IT to see if they are working or not		AR/VR weekly meeting started. Adjusted VR pickup physics and fixed teleportation issue	
8/16/2021	Worked on a presentation for the lab equipment to INL folks		AR/VR weekly meeting started. Started working with Grab interactors to create "tool belt" effect	
8/23/2021	Helped with a workshop at Armory building		AR/VR weekly meeting. Started on RDD project abstract. Fixed Grab interactors. Started on adjusted bomb dispersal and wind pattern. Attended INL training detonation and demoed Argon RF equipment. DRC sync up meeting	
8/30/2021	Updated CAES progress report. Sent the list of new equipment and their description to Jared		AR/VR weekly meetings. Met with Bryan from Argon Electronics to syncronize simulated plumes.	
9/6/2021	created a poster for the lab, Worked on abstract for the CAAV conference		Updated visual assets for RDD project (windows and cars). Ran debugging check for upcoming demo. Met with INL/CAES visualization team. Met with DRC to discuss demo and white paper deliverables. Uploaded white paper deliverables to Mustafa	
9/13/2021	Helped Shishir on the discussion part of the journal		Presented VR RDD demo. Researched trench collapses, particle systems, destructible meshes as they relate to trench collpase. Set out goals for VR and AR projects. Met with INL/CAES visualiztion team.	
9/20/2021	Had a chat with John regarding need for additional development from INL side		Set up AR soil simulation. Started on power point presentation for CAAV. Attended DRC bi-weekly meeting, discussing plans for AR project. Moved ADMS equipment	
9/27/2021	I had a meeting with shishir related to journal paper. He asked for more information like source, type and keywords for each paper		Completed frist phase of soil simulation in Unity. Drafting out thesis proposal. Looking into capabilities of Unity to do destructible objects to simulate trench collapse. Attened INL meeting	
10/4/2021	Updated the poster and sent to Jared for the review		Attended INL meeting. Researching destructible meshes for Unity for trench collapse. Worked on setting up demo in Hololens. Started outline story boards for phase II RDD project.	
10/11/2021	Worked on starting the new "Gaming and Visualization Club" with ASISU. the finished Application process for CAAV Presentation			
10/18/2021	Worked on a quote for upgrades and new equipment		Drafted CAAV presentation. Retooled AR shaders to run on Hololens. Working on RDD phase 2 white paper. Attended INL meeting discussing INL assistance with environment modeling	
10/25/2021	Dr.Farjana and I worked together over the weekend to finish the draft		Met with INL discussing GIS data import into project. Reworked CAAV presentation based on white paper draft. Attend DRC sync up. Working on AR controller integration	
11/1/2021	Dropped the both the concordia machines for upgrades. Ordered two new coolers for the machines.		Prepared VR project for demonstration for CAAV. Put together video for CAAV. Fixed Hololens app deployment. Met with INL planning for CAAV	
11/8/2021	worked on the presentation for the CAAV. Had some discussion with INL folks regarding using Blender.		Met with John Koudlella to review presentation slides Presented at CAAV. Rewriting RDD white paper draft. .	
11/15/2021	Gave access to sindi banda. Attended a meeting for the GVL club. Attended the CMS training for the website.		Attended DRC meeting	
11/22/2021	Did a load testing on the concordia machines. They are failing. Bascailly, I found an issue with the graphic cards on the machines. Need new graphic cards for the machine.		Updated and streamlined VR RDD demo. Met with CAES team about improving cell fracture performance. Attended DRC meeting. Planning on EOC paper. Met with Bryon Marsh on RDD phase 2	
11/29/2021	Worked with Sindi on the website. I provided him a layout of it.		Met with INL discussing trench collapse. Researched blender cell fracturing. Added to RDD outline. Updated AR project with collapsing wall	
12/6/2021	ollowed up with Jack on the Concordia machines status. The concordia originally had 13 computers and we have only 4 of those. We should be able to work with them as long as we have fac ilitator or instructor computers.		Researching plume models, trench failure modes and AR/VR optimization. Starting on outline of EOC document	
12/13/2021	Met with the prof. Caryn Evila. Discussed with her about the possibilities of using VR/AR in her class			
12/20/2021			Met with CAES team. Received documentation of turning physics calculations into animations. Presented Phase 2 RDD outline to Bryon Marsh, working on assigned improvements. Attended DRC weekly meeting. Received trench rescue document from Dr Savage.	
12/27/2021				
1/7/2022	Mostly focusing on working on a new conference paper with shishir.	Worked on the website	Attended INL/CAES meeting. Attended VR Journal Research paper meeting. Working on fixing error with GIS plugin.	Off for break
1/14/2022	Followed up with Jack Bradley on the ADMS. He let me know that we need joysticks. I asked him to shoot an email to Dr.Mashal. An order for four joysticks has been placed. Had chat with the John and his team regarding a conference paper for the VR project. After some discussion, we relaized that we need to some course from CITI training and also submit a report on what we are doing to IRB department. We intent to finish the course next week and come up with a single page proposal to submit to IRB.	made changes to website	Attended INL/CAES meeting. Completed basic IRB training. Continuing to investigate GIS error. Researching netcode for Unity.	UI interaction screen. Continuing work from end of last semester looking at the canvas screen and button functionalities. Buttons work, but can only be triggered by an object held in the hand. There is no interation with the hand directly. I spent the week researching a solution. Current solution is to set a table next to the screen with a "wand" to touch the buttons
1/21/2022	updated the inventory list in the excel sheet. We got the joysticks. I took them from ellen and gave it to the COSE IT folks.	made changes to website	Attended INL/CAES meeting. Working on IRB research proposal. Learning and integrating ARC GIS plugin. Assisted in inventory	Continued work on "Netcode". There is documentation for this at the following link: https://docs-multiplayer.unity3d.com/docs/tutorials/goldenpath_series/goldenpath_foundation_module. I spent my hours creating a non-VR 3D game to practice implementing these multi-player functionalities. Not an easy task
1/28/2022	Finished CITI traning. Working with Jack on getting the documentation done with IRB.		Attended INL/CAES meeting. Finished and submitted IRB research proposal. Integrated ARCGIS plugin. Helped setup oculus for club demo.	More Netcode, following tutorials. The "player" instantiates, but I am unsure how to implement the game build on another machine.
2/4/2022	Worked on preparation for the Spring Organisation fair. Worked with Grad school in getting a TV for the the fair. Worked with Jack on how to plan for the fair. Worked with Laura on returning the Joysticks. I had to go to UPS a couple of times to return them. They didnt accept the return due to wrong return form. Worked on the setting up the tables for the new extension part of the lab	Helped arrange desks in lab	Attended INL meeting. Updated GIS background model to blend with area better. Integrated GIS updated in GITHUB storage. Helped setup side lab. Finished CITI Benign Behavior Intervention training.	Began working on the poster for the upcoming DPRC thing
2/11/2022	Retuned the joy sticks. Got the website ready for the GVL lab. Conducted the first event for the GVL club Spring organisation fair event. Worked on setting up the machines in the new extension part of the lab	student fair/ learning github and unity	Attended INL/CAES meeting. Continued editing GIS model. Added foundation for human AI actors in scene.	This week I was give a task for another project by Dr. Mashal that took all of my work hours

Appendix 2: Sample Student Activities

Dates	Uma Shankar Medasetti	Sindi Banda	Jack Dunker	Zack Free
2/18/2022		Practicing on unity to gain familirity on how it works. Went through assigned videos on youtube.	Attended INL/CAES meeting. Finished CITI Behavioral Intervention Training. Researching how to handle crowds of people in Unity.	This week I worked fewer hours to study for some midterm tests
2/25/2022		Practicing on unity (gaining familiarity with VR And AR how it works on unity	Attended INL/CAES meeting. Finished DPRC poster draft. Working on Unity animations and AI	Continued researching the Netcode issue. Not much progress made.
3/4/2022		Practicing on unity learning how to create 3d objects and how to interact with them / assigned vides by Jack	Attended INL/CAES meeting. Attended DRC meeting. Researching explosive aerosol dispersal. Resubmitted IRB proposal. Finalised DPRC poster draft	Focused on school projects
3/11/2022		Practicing on unity, learning C# basics using a demo game / assigned vides by Jack	Submitted DPRC poster. Attended INL/CAES meeting. Working on extending crowd animations. Distributed DPRC flyers. Researching NARAC dispersion modeling.	Busy with school projects due
3/18/2022	In India. Worked on the certification for the IRB	working on research paper	Attended INL/CAES meeting. Reviewing HOTSPOT modeling radiation modeling program. Fixed errors in GIS landscape. Resubmitted IRB review request	Tried to catch up on CITI trainings. Completed 2. Researched relevent Unity topics. No pushes to repository though
3/25/2022	In India, worked on the website. Worked on the certification for the IRB		Attended INL/CAES meeting. Fixed error in AI pathfinding. Working on final draft of DPRC poster. Continued fixing GIS errors.	No hours worked during Spring break
4/1/2022	Worked on the poster.	Practicing on unity (worked on scripting using C#, / assigned vides by Jack	Submitted final draft of DPRC poster. Studying current environmental dispersion models for comparsion.	Preparations for DPRC Conference
4/8/2022	Mostly helped with the conference on those two days. Presented the poster. Had a meeting about the IRB researsch proposal	attended the DPRC Conference	Drafting research problems. Reviewing VR tasks for volunteers.	DPRC Conference
4/15/2022		Doing task given by Dr Mashal (Scaaned business Cards into pdf document)	Attended INL meeting. Scheduling student volunteers. Helping Nirajian with lab setup. Prepping evaluation questions	Task assigned for another project
4/22/2022		Was getting ready for exams	Attended INL meeting. Running student volunteers through research scenario and collecting surveys.	Focused on school projects; came in briefly to update Github and stay familiar with new changes to repository
4/29/2022		I had eaxms, did not work on anything	Reviewing first wave research data and assessing future performance changes	Came in to lab to clean up before end of semester;
5/6/2022		learning how to package the project	Continuing research review. Attended INL meeting. Attended DRC monthly meeting. Reviewing draft for RDD white paper	
5/13/2022	Meeting with Dr.Farjana and her team regarding the collaboration. Getting data/questions ready for the study. Send emails to professors for inviting the students.	Wrote the research report / learming on how to package the project into an exe file for easy launching and sharing.	Working on RDD white paper and VR research paper	
5/20/2022		Made the build for windows ,	Work on getting project packaged into standalone exe. Gathering VR research material.	
5/27/2022		learning on how to make a build for the oculus	Finished reviewing VR research material. Looking for novel research questions	
6/3/2022	not much. Just met couple of students who took our survey. Finished the website work for Dr.Mustaf Mashal. The functionaloty didn't work as expected for some reason. I will take a look at it next week.	added user interface button so the that user can exit the game	Bug fixing standalone project. Submitted white paper for review by Bryon	
6/10/2022		building an apk for the quest, build was not to run requested help form Jack.	Reviewed and edited white paper to smaller more focused length. Continue bug fixes for VR project.	
6/17/2022		Worked on the Quest build, it diid not work. Jack helped to figure what could be the problem.	Working deploying VR project to Occulus. Updating white paper. Attending CAES meeting.	
7/8/2022	Reviewed some papers and came up bunch of keywords. Had our first meeting with the Dr.Vaibhav. He gave me a task to read by next week. I will be working	Made a demo with Photon Network and added Network Player. creating network player arvata and Debbugging errors in the scripts . Creating Room so that both		

Appendix 3: Expenditure Report

Data_Description				Accounted Budget	Year-to-Date													Encumbrances	Reservations	Total by ROWS
Fiscal_Month				Temporary Budget	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Subtotal	YTD	YTD	
				Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount
Index Only	Account			Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value
AHRC48_APPR IGEM Response Complex for Eme	Labor			244,000.00	(9,975.88)	(29,067.68)	(17,526.50)	(16,274.93)	(12,599.57)	(12,406.89)	(13,754.92)	(11,829.83)	(15,127.96)	(23,761.59)	(14,029.76)	(20,852.79)	(197,208.30)	0.00	0.00	46,791.70
		610_Salaries		198,600.00	(2,046.16)	(5,846.16)	(5,846.16)	(10,700.91)	(7,133.94)	(7,133.94)	(6,490.05)	(7,777.79)	(9,709.42)	(14,564.13)	(9,709.42)	(8,769.24)	(95,727.32)	0.00	0.00	102,872.68
		620_Irregular Help		0.00	(6,864.45)	(20,108.27)	(8,971.64)	(2,186.75)	(3,089.62)	(2,903.82)	(4,918.84)	(1,744.36)	(2,866.52)	(5,331.28)	(1,807.52)	(9,497.58)	(70,290.65)	0.00	0.00	(70,290.65)
		630_Fringe Benefits		45,400.00	(1,065.27)	(3,113.25)	(2,708.70)	(3,387.27)	(2,376.01)	(2,369.13)	(2,346.03)	(2,307.68)	(2,552.02)	(3,866.18)	(2,512.82)	(2,585.97)	(31,190.33)	(0.00)	0.00	14,209.67
	Direct Expenditures			39,100.00	(313.54)	(9,029.76)	(11,333.96)	(10,262.34)	(2,947.73)	(59.33)	(12,361.84)	(1,523.12)	(817.00)	(1,506.66)	(4,576.93)	(18,690.59)	(73,422.80)	0.00	0.00	(34,322.80)
		700_Travel		6,000.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6,000.00
		720_Services		33,100.00	(93.50)	(1,971.85)	(1,927.96)	(854.00)	(187.00)	(32.05)	(187.00)	(93.50)	(817.00)	(510.20)	(1,625.15)	(8,838.54)	(17,137.75)	0.00	0.00	15,962.25
			721_Employee Development Services	0.00	0.00	0.00	0.00	(400.00)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(400.00)	0.00	0.00	(400.00)
			724_Professional Services	0.00	0.00	(355.24)	(1,474.46)	0.00	0.00	0.00	0.00	0.00	(630.00)	0.00	(1,312.61)	(8,675.04)	(12,447.35)	0.00	0.00	(12,447.35)
			727_Administrative Services	0.00	0.00	(948.11)	(310.00)	(310.50)	0.00	(32.05)	0.00	0.00	0.00	(31.20)	(219.04)	(48.00)	(1,898.90)	0.00	0.00	(1,898.90)
			729_Repair and Maintenance Services	0.00	0.00	0.00	(50.00)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(50.00)	0.00	0.00	(50.00)
			741_Rentals and Operating Leases	0.00	(93.50)	(668.50)	(93.50)	(143.50)	(187.00)	0.00	(187.00)	(93.50)	(187.00)	(418.50)	(93.50)	(115.50)	(2,281.00)	0.00	0.00	(2,281.00)
			761_Utility Charges	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(60.50)	0.00	0.00	(60.50)	0.00	0.00	(60.50)
		730_Supplies		0.00	(220.04)	(7,057.91)	(4,095.23)	(901.92)	(957.99)	(27.28)	(4,586.84)	(540.95)	0.00	(996.46)	(2,951.78)	(2,128.08)	(24,464.48)	0.00	0.00	(24,464.48)
			731_Administrative Supplies	0.00	(70.70)	(1,449.95)	(2,397.91)	0.00	0.00	0.00	0.00	(119.99)	0.00	0.00	(883.79)	(647.64)	(5,569.98)	0.00	0.00	(5,569.98)
			732_Fuel and Lubricants	0.00	(96.97)	(68.68)	(20.30)	0.00	(114.31)	0.00	(140.10)	(160.13)	0.00	0.00	(189.85)	0.00	(790.34)	0.00	0.00	(790.34)
			733_Computer Supplies	0.00	0.00	(84.79)	(139.96)	0.00	0.00	0.00	0.00	(114.49)	0.00	0.00	0.00	0.00	(339.24)	0.00	0.00	(339.24)
			734_Repair and Maintenance Supplies	0.00	0.00	(105.00)	0.00	0.00	0.00	0.00	(42.01)	0.00	0.00	0.00	(443.69)	(90.00)	(680.70)	0.00	0.00	(680.70)
			736_Institutional/Specific Use	0.00	(52.37)	(5,349.49)	(1,537.06)	(901.92)	(843.68)	(27.28)	(4,404.73)	(146.34)	0.00	(996.46)	(1,434.45)	(1,390.44)	(17,084.22)	0.00	0.00	(17,084.22)
		800_Capital Expense		0.00	0.00	0.00	(5,310.77)	(8,506.42)	(1,802.74)	0.00	(7,588.00)	(888.67)	0.00	0.00	0.00	(7,723.97)	(31,820.57)	0.00	0.00	(31,820.57)
			820C_> $5K Buildings and Improvements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(6,700.00)	0.00	0.00	0.00	0.00	0.00	(6,700.00)	0.00	0.00	(6,700.00)
			830_Computer Equipment	0.00	0.00	0.00	0.00	(8,506.42)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(8,506.42)	0.00	0.00	(8,506.42)
			845_Office Equipment	0.00	0.00	0.00	(3,620.80)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(3,620.80)	0.00	0.00	(3,620.80)
			850_Specific Use Equipment	0.00	0.00	0.00	(1,689.97)	0.00	(1,802.74)	0.00	(888.00)	(888.67)	0.00	0.00	0.00	0.00	(5,269.38)	0.00	0.00	(5,269.38)
			850C_> $5K Specific Use Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(7,723.97)	(7,723.97)	0.00	0.00	(7,723.97)
	Subtotal			283,100.00	(10,289.42)	(38,097.44)	(28,860.46)	(26,537.27)	(15,547.30)	(12,466.22)	(26,116.76)	(13,352.95)	(15,944.96)	(25,268.25)	(18,606.69)	(39,543.38)	(270,631.10)	0.00	0.00	12,468.90
Total by COLUMNS				283,100.00	(10,289.42)	(38,097.44)	(28,860.46)	(26,537.27)	(15,547.30)	(12,466.22)	(26,116.76)	(13,352.95)	(15,944.96)	(25,268.25)	(18,606.69)	(39,543.38)	(270,631.10)	0.00	0.00	12,468.90

Disaster Preparedness & Response Conference, Spring 2022

The Idaho State University hosted a two-day Disaster Preparedness and Response Conference on April 8-9, 2022. The conference covered a variety of emergency management topics by guest speakers geared towards both students and professionals. A portion of the conference was dedicated to showcasing the innovation of ISU students/research. Workshops and a demonstration of an outdoor rescue highlighted the capabilities of the Disaster Response Complex

Feedback was obtained from the participants of the conference for future improvement (n=30). Table 1 demonstrates the quality of the conference, if it met the audiences' expectations and if the participants would recommend it to others.

Table 1: The quality of the conference, audiences' expectations, recommendation to others (n=30 responses).

	N=30 (%)
Did the conference content meet your expectations?	
Yes	27 (90)
No	0
Maybe	3 (10)
How would you rate the quality of the conference?	
Excellent	11 (36.6)
Good	16 (53.3)
Acceptable	2 (6.6)
Needs improvement	1 (3.3)
Would you recommend this conference to others?	
Yes	29 (96.6)
Maybe	1 (3.3)

Comments were also taken from the participants regarding training and equipment material, speakers and improving the conference in future. Their comments are organized into the following themes, and sub-themes:

Table 2: Themes, sub-themes and codes

Themes	Sub-themes	Number of coded segments (n=30 feedback forms)
General comments about the conference		6
Comments about the speakers	Positive comments	25
	Negative comments	2
Training, drill material and equipment	Positive comments	7
	Negative comments	1

Benefits of the conference	Training related to disaster response & management	1
	Showcasing student research	1
	Showcasing ISU department & DRC	2
	Increase in disaster response & management	17
	Networking	16
Recommendations	Partnerships	3
	College journal	1
	Topics	2
	Making sessions more engaging	2
	Conference logistics	18
	Marketing	1
	Group focused sessions	4

The audience gave positive comments about the conference (n=6 comments). The comments about the speakers were also welcoming (n=25 comments), however, some participants felt there was a need for improvement (n=2 comments):

"Loved the wide variety of trainers..(P1)….Great instructors. High passion and energy for the industry…(P28)…..They were all very learned and had a good grasp of the subject. They shared their personal experiences, which were very insightful…(P15)…Some were good, some were not! Some did not offer any good ideas or concepts that I can use in my work. Just stories…(P10).. Some were highly involved in their discipline and vocabulary which made following their presentations more difficult… (P5)"

Another issue raised was the lack of clarity on certain topics: *"Some instructors mentioned they were not certain if they were supposed to cover certain things or even what they were supposed to talk about..(P9)"*

The participants also applauded the equipment, training and drill material. Increase in disaster related knowledge (n= 17 comments), and networking with relevant people in the field (n=16 comments) were major benefits narrated by the participants.

"This gave me a great deal of information that I can take back to work to use in advancing our emergency management…(P9)…Great networking opportunities …!!! (P22)….It was a good mix of different topics……(P4)…Increased knowledge and awareness. How "my" part in an emergency fits with others. How I can better help others recognize the value my contribution could be (voluntary organizations)…(P11).."

It was clear that the audience wanted to have another similar conference after a year. A prominent recommendation was to improve the logistic arrangements at the DRC: including improving the restrooms, chairs for the audience, mics and speakers (n= 18 comments). People also recommended to have focused sessions for specific target audiences e.g., students, healthcare professionals, emergency managers etc. One of the thought-provoking questions was:

"Who was the target audience? (P17)"

Figure 1 shows the word cloud of the comments received from the participants.

Figure 1: Word Cloud

Thus, our analysis shows that the conference was successful in meeting the expectations of the audience. We hope to incorporate the participants suggestions and recommendations in improving the conference in future.

ISBOE HERC-IGEM Project

Yr 3: Final Report

Project Title:	Cellulosic 3D Printing of Modular Building Assemblies
Principal Investigator:	Dr. Armando McDonald
Institution:	University of Idaho (lead) with subcontract to Boise State University
Grant Number:	IGEM 20-002
Award Amount:	$349,900
Fiscal Period:	July 1, 2021 – June 30, 2022
Final Report Submitted to SBOE:	August 2022
Reporting Period:	July 1, 2021 – June 30, 2022

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1) Summary of project accomplishments

The accomplishments and plans for the project objective identified in the original proposal are summarized. A summary of accomplishments for the overall project management and engagement activities are also summarized below.

Objective: *Identify an Idaho, highly energy- and process efficient, scaled approach to residential and low-rise commercial modular construction using 3D printing methods.*

Team: Armando McDonald (UI – Forest & Sustainable Products, PI); Ken Baker (UI - Idaho Design Lab, PI); Michael Maughan (UI – Mechanical Engineering), Damon Woods (UI – Idaho Design Lab), Tao Xing (UI – Mechanical Engineering), Ralph Budwig (UI – Mechanical Engineering), Casey Cline (BSU – Construction Management), Kirsten Davis (BSU – Construction Management), and Ty Morrison (BSU – Construction Management).

Team background and overall goals: This new team was formed based on this project that required multidisciplinary experience to integrate resin formulation chemistry, composite materials, 3D printing, mechanical engineering, energy efficiency, manufacturing and building design, and construction management to develop a printing platform for construction. Research was focused on developing a 3D printing system which utilized wood residues and a low temperature cured resin (binder) to deposit an extrudate to form a printed modular construction product. In addition, concepts for modular construction design were created and assessed for their feasibility in construction. Ultimately, research will advance solutions that can be applied in manufacturing and construction sectors; producing economic value from waste to enhance Idaho-based industries.

Accomplishments of this project:

The following provides detail of progress over the 3-year project, towards the aims described in the original proposal plan.

1. The project will research design for identification of adhesive/binder, flow, and cure attributes for a wood fiber cold print process.

   (McDonald and Maughan). Investigations were done to identify and evaluate suitable low cost and low temperature cure resins that would be suitable for use in additive manufacturing (AM). Procedures to monitor resin cure were developed by thermal analysis and rheometry to evaluate various commercial resins. Two resin systems were finally identified that were suitable, sodium silicate (SS) and phenol-resorcinol-formaldehyde (PRF). Formulations of resin and wood fiber (sourced from sawmill residues and screened into different mesh size fractions) blends (wood-SS and wood-PRF) were assessed for their flow behavior (rheology) (Figure 1) and extrudability. Ultimately, several formulations were deemed suitable wood-SS (45:55 and 50:50) and wood-PRF (50:50). A high shear blender was required to fully mix the resin and wood fibers prior to rheological and extrusion studies. A <40 mesh wood fiber fraction produced composites with good surface finish. Various curing regimes were investigated (time and temperature) to obtain material with no surface checks (no defects). The cured wood-SS and wood-PRF composites were evaluated for their flexural properties and fire resistance. The composites had flexural properties better than particleboard and were fire resistant (Figure 1). In addition, we have investigated the use of CO_2 to

accelerate the curing of the wood-SS composites with the benefit of sequestering carbon in the composite product. **This section of work was the foundation for developing a formulation that could be integrated into a 3D printing system based on wood fiber and fire resistant.** Ph.D. graduate student *Berlinda Orji* in Environmental Science is currently working on this project topic and expected to complete her studies in Spring 2023. One publication has been published (*European Journal of Wood and Wood Products,* DOI: 10.1007/s00107-022-01861-z) and another two will be submitted soon. In addition, two presentations at international conferences and one 3D-printing workshop have been given.

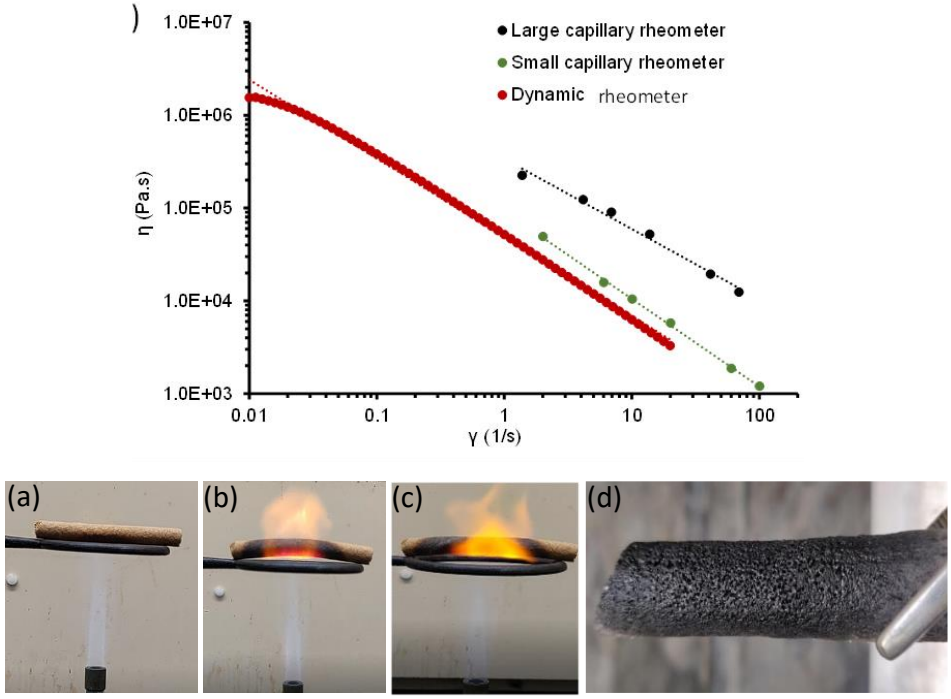


Figure 1. (Top row) viscosity versus shear rate (flow curves) plots of wood-SS (50:50) blend by dynamic and capillary rheometry at 22°C and (Bottom row) Photographs of the wood-SS (50:50) composite during a Bunsen burner flame test at (a) 0 min, (b) 2 min, (c) 4 min, and (d) after 5 min test completed.

2. <u>The project will develop a prototypical schematic design for a 3D printer that will print building sections (e.g., panels) from wood/natural fibers using a liquid-based chemical binder.</u>

(Maughan and McDonald). Complementing the wood-resin formulation was the development of a 3D printing platform. We conducted a literature review on 3D printing of biomaterials. The review revealed that 3D printing of environmentally friendly wood composites is a field that is newly emerging. Based on the mechanical properties of preliminary composite material samples (see above), we selected a plunger/barrel batch extrusion (e.g. syringe) approach as a preliminary test for extruding and depositing the composite mixture and this will require a high level of force which was achieved using a universal testing machine. The system was successful in extruding wood-resin

mixture to produce a rod out of the nozzle at the bottom of the barrel and this validated our "proof of concept". Based on these findings a single screw extruder (35 mm dia. Screw with an 18 mm dia. nozzle) was purchased for continuous extrusion required for additive manufacturing (AM). To handle the required torque for extrusion a 1 hp motor was installed (original motor was 1/3 hp) and the screw flights modified for extruding the wood-resin mixtures as compared to molten plastic which it was designed for. Extrusion parameters, which are critical for producing smooth rods (Figure 2) and flow behavior (rheology) of this mixture, govern how to produce defect free prints. We have refined the extrusion technique to eliminate surface defects (shark-skin). This defect is caused by friction and shear gradient within the flowing mixture. **Outcome: the extruder was successful in producing composite samples for evaluation** (see above). Graduate student *Conal Thie* worked on this section of the project and completed his M.S. in Mechanical Engineering thesis in Summer 2021 and is now employed as an engineer in Boise. In addition, one presentation at an international conference and one workshop on 3D-printing have been given as well as a published journal article (see above).

Figure 2. Photographs of (a) smooth extruded wood-SS (50:50) rods and (b) extruded wood-SS showing sharkskin.

(Xing and Maughan) A multi-core processor computer was purchased for conducting computational fluid dynamics simulations (CFD). We conducted additional testing and used this as a comparison to validate CFD flow simulations of the composite mixture. The flow simulations allowed us to develop a model of the continuous flow extruder which is necessary for component sizing and determining mixture compression. Mixture compression is a key variable dictating mechanical properties such as bending strength and stiffness. Figure 3 shows CFD-generated pressure and temperature plots representing flow within the extruder. The pressure results show a good agreement with experimental data; however, the temperature results couldn't predict the experimental data. Therefore, we employed a discrete element method (DEM) to model the wood fibers during the extrusion process using ROCKY DEM software which overcome the CFD model limitations (Figure 4). Ph.D. student *Anas Nawafleh* in Mechanical Engineering was working on this project topic and expected to complete his studies in 2023-2024.

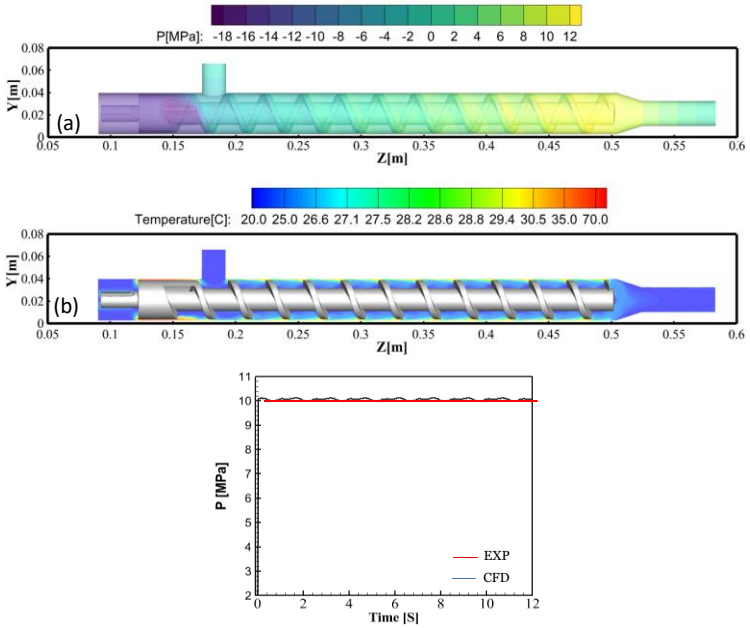
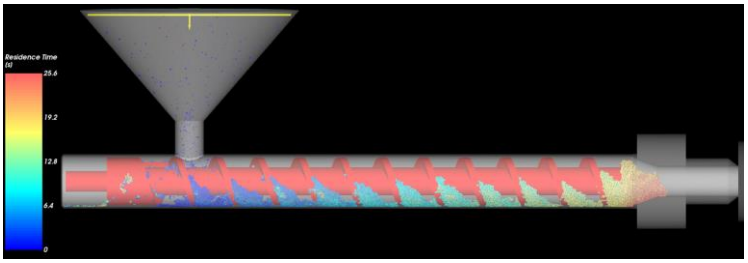
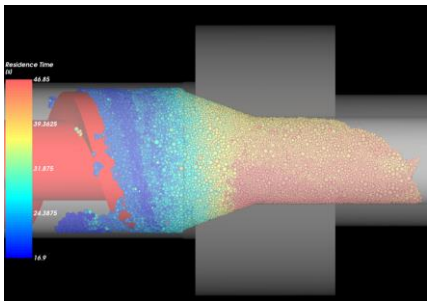


Figure 3. Single screw extrusion CFD simulation: (a) Contours of pressure, (b) Contours of temperature, and (c) Comparison between CFD and experiment.



(a)



(b)

Figure 4 – Single screw extrusion DEM simulation: (a) Contours of particles' residence time at 25.6 s, and (b) contours of particles' residence time at 46.85 s in the die.

(Maughan and McDonald). A 3D printer-frame was designed for additive manufacturing (AM) wood composite materials by an undergraduate researcher for a 2' x 3' x 2' build envelope. The printer gantry was then refined and built by a graduate student utilizing stepper motors for position control (Figure 5). The 3D printer uses a Smoothie Board CNC controller and Pronterface software. Extrusion

was determined to be necessary for sustained 3D printing using a single screw extruder (discussed above). The challenge was connecting the extruder (~75 lbs) to the print head without putting too much strain on the gantry system. A high-pressure flexible hose with compression fittings was identified as an attachment method to convey the wood-resin (SS) mix from the extruder barrel to the print head nozzle (Figure 5). This eliminated the dead weight on the printer gantry. A rectangular nozzle was designed to produce a continuous ribbon in support of project goals to print a wall panel. Also identified during printing large structures was the extruder barrel heated up, due to friction, which prematurely cured the resin and the extrudate hardened impeding interlayer bonding. A heat exchanger cooling system was then fabricated on the extruder barrel to maintain temperature (~72°F). This cooling system helped maintain good flowability of the wood-resin mix and improve interlayer adhesion. In addition, a rotating print head was developed to print cross-beam sections (e.g. stud wall) as well as panels. Code was developed to print panels. **This section of work proved our "proof of concept" in AM of a wood composites panel using low temperature cure resins.** Graduate student *Robert Carne* worked on this section of the project and completed his M.S. in Mechanical Engineering thesis in Summer 2022 and has now started his Ph.D. on 3D printing of wood composites.

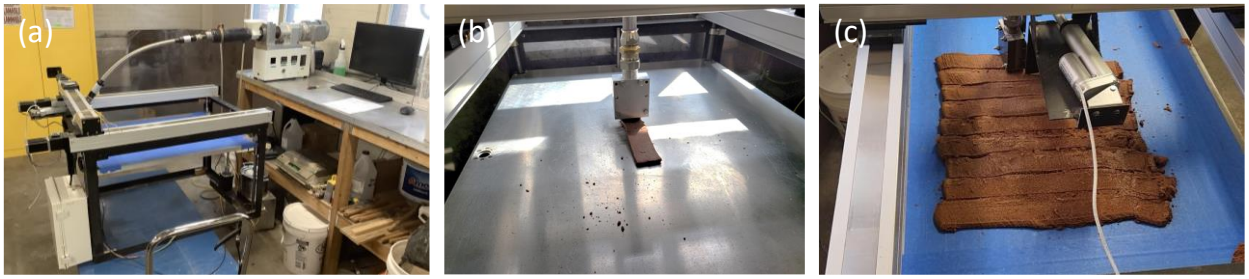


Figure 5. Photographs of (a) 3D-printer, (b) starting a ribbon print, and (c) panel print showing the rotatable nozzle.

3. <u>The project will develop a business case for the proposed printing process to market.</u>

(Woods, Baker, and Budwig). The Integrated Design Lab team developed an instrument and method based on ASTM C177 to evaluate the thermal properties of wood composite panels (wood-SS). The results showed that the wood-SS formulations had thermal conductivity values which ranged from 0.08-0.15 W/mK and were largely dependent on panel density. The thermal properties were comparable to other wood-based composites currently used in construction. In addition, a preliminary life cycle assessment (LCA) was performed on a wall section of the 3D-printed wall assembly, as well as for other common residential wall types (Structural insulated panels (SIPS)), wood frame, steel frame, concrete masonry units (CMU), and 3-layer cross-laminated timber (CLT)). The 3D-printed wall design is shown in Figure 6. The main factor under consideration was the total energy impact. It was found that the proposed 3D-print wall had the best performance in the materials stage and was a close runner up in the building energy usage and end of life stages (Figure 6). The 3D wall design has potential to decrease energy usage in the residential and light commercial building types. If additional incremental improvements are achieved in the envelope performance and manufacturing stages, the 3D-printed wall could become one of the lowest energy consuming

wall types available. Graduate student *Tais Mitchell* worked on this section of the project and completed his M.S. in Mechanical Engineering thesis in Fall 2021 and is now employed as an engineer in ID.

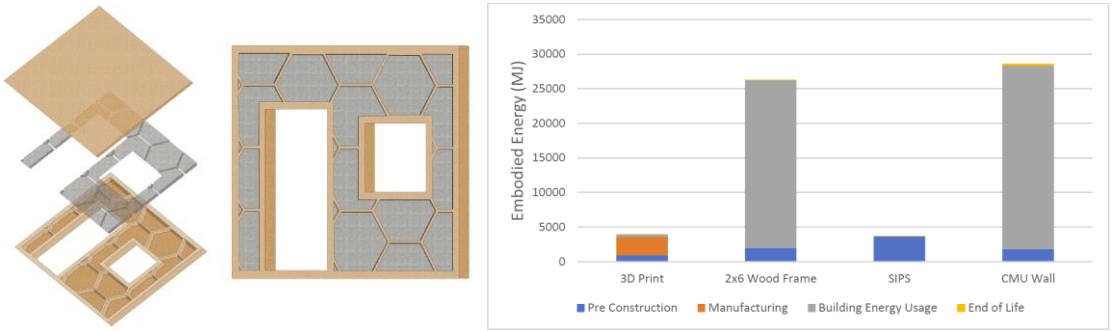


Figure 6. (left) 3D-printed wall design and (right) total energy impact comparison

(Woods). A 3D "weaving" printer was designed and developed at IDL. The goal was to reinforce the structures with continuous natural fibers (jute and cotton) using an AM process. The weaving machine built in the same design framework as a 3D printer (Figure 7) which included a fiber spool and a fiber and resin placement nozzle. The nozzle "deposits" the resinated fiber along the pin bed. Using a modified program designed for a CNC machines, the G-code was created to produce desired "weft and warp" patterns (Figure 7). The tension of the pin beds allowed the fiber to weave upwards in the Z-direction. MS student in Architecture, Joseph Sedillo, worked on the design and fabrication of the unit and expected to graduate spring 2024.

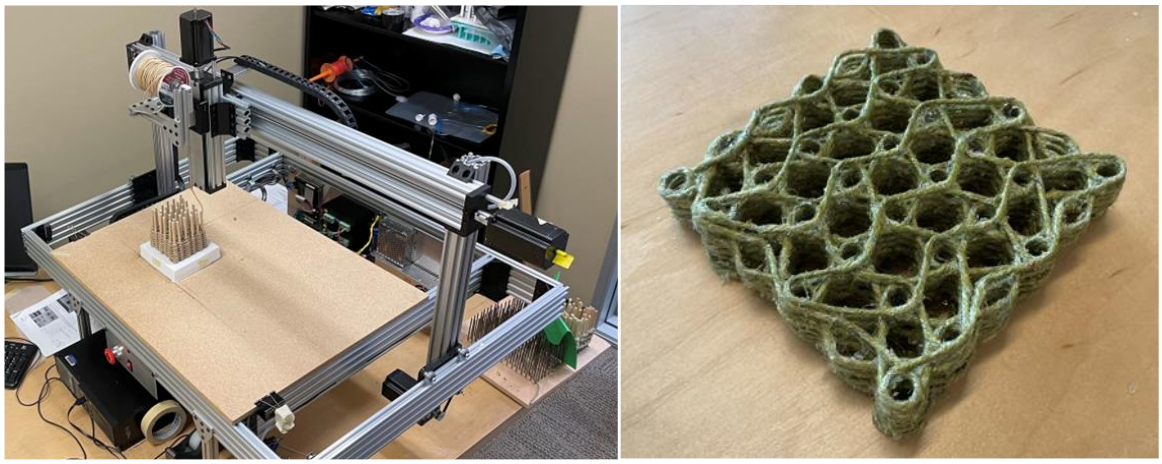


Figure 7. (left) 3D-weaving printer and (right) jute fiber-resin printed composite weave

(Baker) The IDL team together with BSU and UI Moscow campus utilized a gift from the Northwest Energy Efficiency Alliance to support two women architectural students (Lyndsay Watkins and Kelsey Ramsey MS in Architecture graduated in May 2022) who conducted a literature review,

business case development, and graphic presentations of grant accomplishments. A business case was developed – *Our goal is to develop a reliable, cost-effective, and environmentally friendly process for the additive manufacturing of modular panels (wall, floor, and roof assemblies) predominantly from wood waste, utilizing a novel cold-setting print media*. An overview of the business case is shown in Figures 8 and 9.

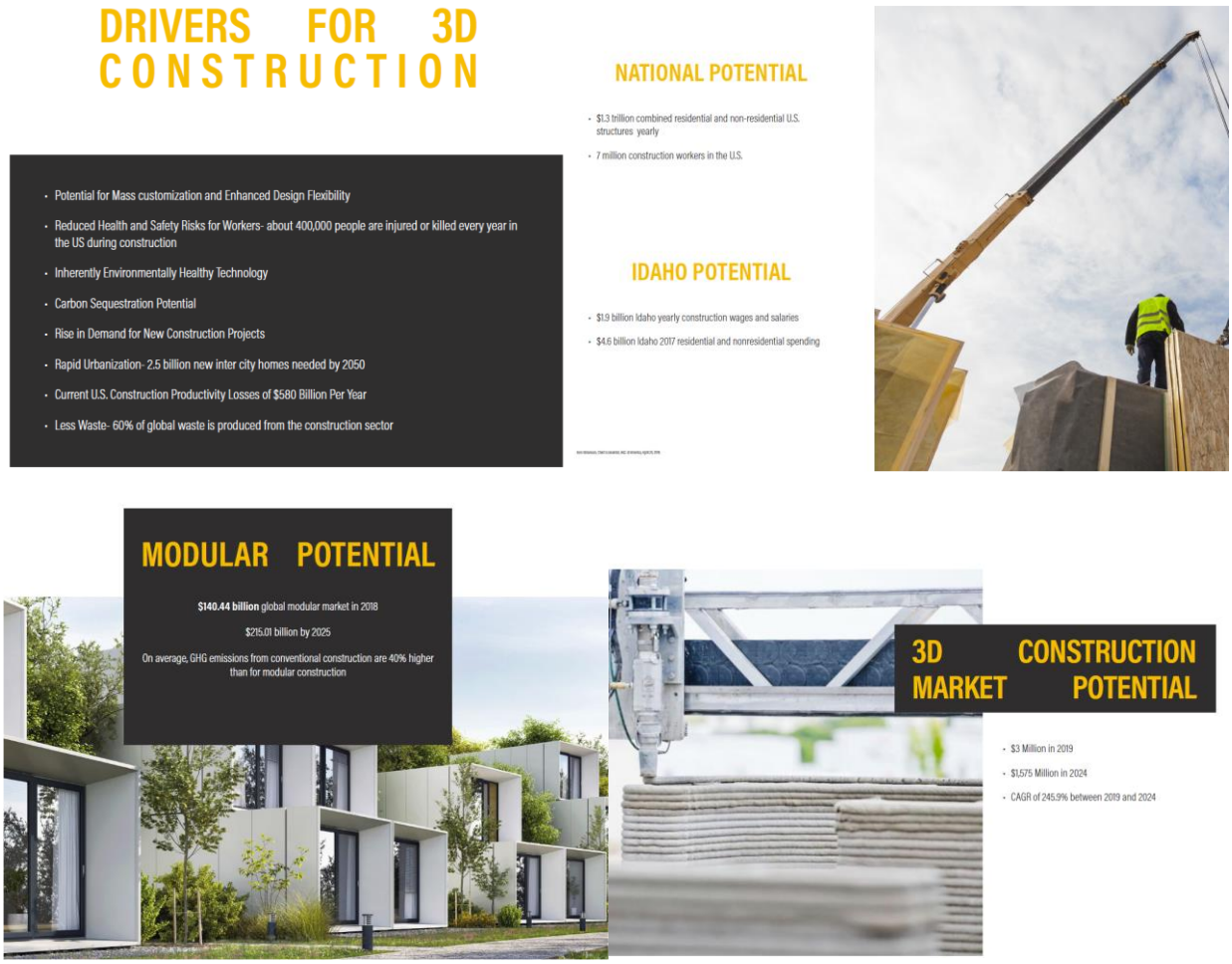


Figure 8. Drivers and markets for 3D construction

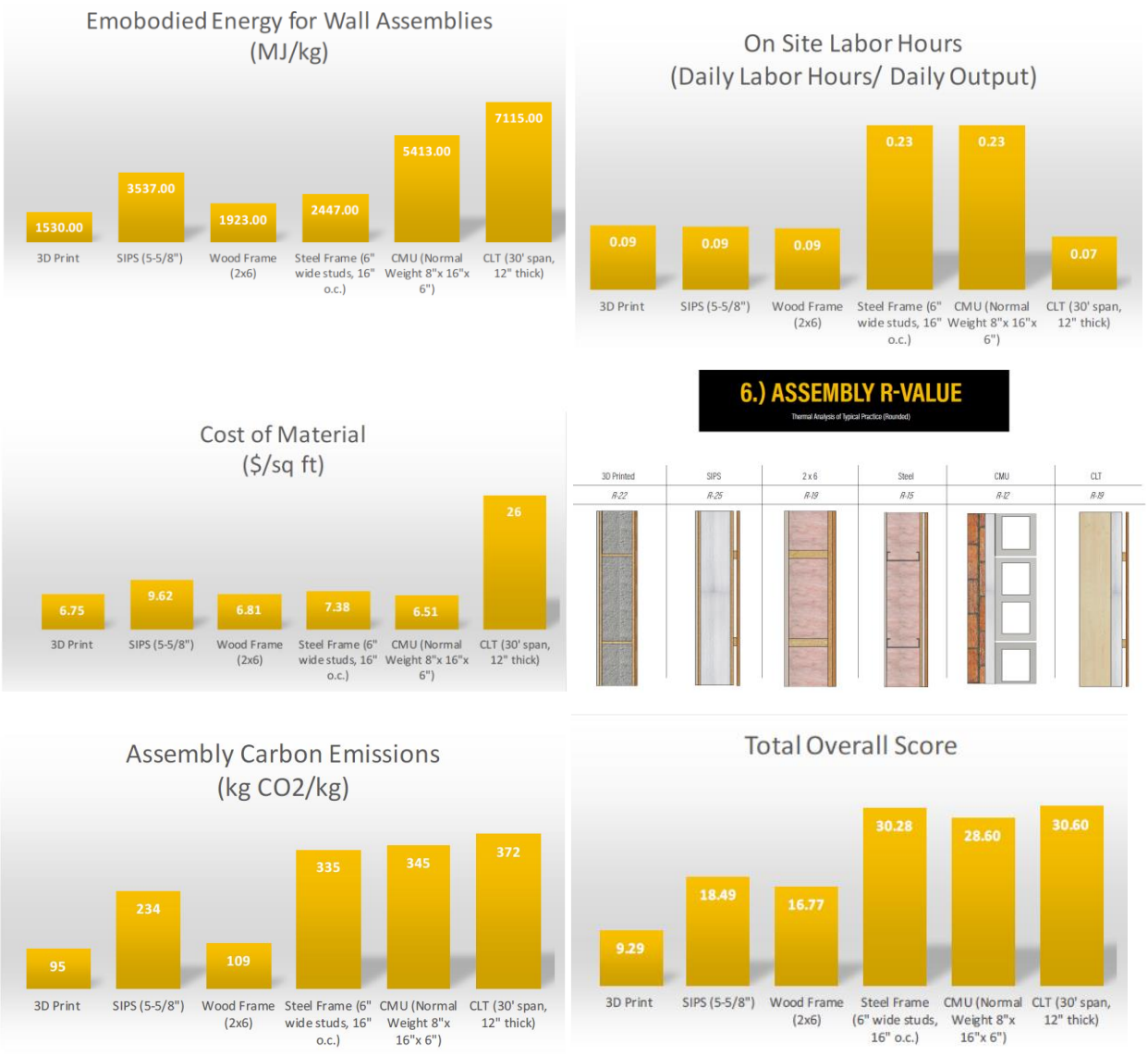


Figure 9. Comparison of embodied energy, labor costs, material costs, R-values, CO_2 emissions and overall score of six different wall construction types.

(Cline, Davis and Morrison). The BSU team worked with two undergraduate students in Construction Management on how to use 3D printed panels in construction. Printed panels (10" x 10") were provided by UI for assessment. The outcomes were:

- *Analyzed constructability for the planned panels*. This analysis provided an overview of the site issues with modular construction such as panel construction, transportation, and connections, as well as thoughts about end user expectations.
- *Assisted in development of the business case for the 3D printed panels*. Evaluation of the best market (residential, light commercial, etc.) for printed panels like this based on constructability was also provided.

- *Developed a construction sequencing model*. 3D modelling and video editing software was used to develop models and a video to begin determining optimal panel configurations and ideal construction sequencing of panels. This work included a simulation of full-size panel printing, proposed panel shapes, and a possible construction sequence.
- *Assisted with prioritization of desirable features to improve constructability*. Provided troubleshooting on the project and developed priorities based on constructability aspects. Examples of these priorities include items such as: water resistance, durability, ability to modify panels at job site with commonly available construction tools.
- *Evaluated 3D printed panels* for connection options, machining, nailing, fasteners, caulking and suitability for finishes.
- *Investigated how constructability analysis might be taught to students*. An initial framework for teaching students' construction related aspects that should be considered in the design of new construction materials was developed. This initial framework for teaching constructability analysis on the modular panel development can later be expanded to help teach students working in a broader array of construction materials development projects.

The team presented two poster presentations on their work at (i) 58th Annual Associated Schools of Construction International Conference (2022) and (ii) American Society for Engineering Education (2022).

2. Summary of budget expenditures for Y 3 (July 1, 2021 – Jun 31, 2022)

A detailed expenditure report is provided in Appendix A. The table below summarizes the spending in the major budget categories, relative to the budgeted amounts for Year 3. The expenditure report was run on August 2022. The average "burn rate" for the entire grant (including BSU subcontract) was $21.7k/month (or 6.2%). A total of 25.38% of the budget remains which is $88,807.33 returned to SBOE.

	Funds		
	Budget	**Expended**	**Difference**
Salaries/Hourly/Fringe	$ 194,100.00	$136,563.19	$ 57,536.81
Travel	$ 7,400.00	$ 3,037.43	$ 4,362.57
Other Expense	$ 19,000.00	$ 20,006.80	$ (1,006.80)
Capital Equipment	$ -	$ -	$ -
Small Equipment	$ -	$ -	$ -
Overhead	$ -	$ -	$ -
Trustee Benefits	$ 51,600.00	$ 50,228.00	$ 1,372.00
BSU Subcontract	$ 77,800.00	$ 51,257.25	$ 26,542.75
Total without Subcontract	$ 272,100.00	$209,835.42	$ 62,264.58
Total With Subcontract	$ 349,900.00	$261,092.67	$ 88,807.33

3. Demonstration of economic development/impact

- Patents, copyrights, Plant Variety Protection Certificates received or pending

Drs. McDonald, Maughan and Baker submitted an invention disclosure to the UI Technology Transfer office. They provided feedback and were not willing to support submission to the Patent Office.

- Private sector engagement

This project work involves considerable engagement with stakeholders. The additive manufacturing of wood composites has received considerable interest from the Forest Products sector (Boise Cascade Corp. (contact Dann Briscoe) and the 3D printing industry (Massivit 3D Printing Technologies Ltd. (Contact - Ben Arnold); Continuous Composites (contact - Nathan Stranburg); and Alquist 3D (contacts - Aaron Hackett and Aiman Hussein)). These companies have been selected to be part of our stakeholder advisory board on the wood composites additive manufacturing program. Boise Cascade is an affiliate member of the wood composites additive manufacturing program by contributing $10,000. In addition, Drs. McDonald and Maughan were contacted by the US Army and USDA-Forest Products Laboratory to discuss our wood composites AM research at two virtual meetings and were interested in moving forward on a collaborative project. This resulted in submitting a preproposal to the Department of Defense "*Wood-composite structures by additive manufacturing*".

- Jobs created

Several of the research assistant and all of student research assistantship positions described in the next section were newly created during this grant.

4. Numbers of faculty and student participation

The numbers of faculty, students and other researchers participating are as follows:

Faculty:	10 (7 UI and 3 BSU)
Graduate Students:	8 (6 UI (2 whom are from groups underrepresented in STEM)
Undergraduate Students:	6 (4 at UI (3 from groups underrepresented in STEM), 2 at BSU)

More details on staffing:

McDonald staffing: 1 PhD student in Environmental Science. 1 woman.
Baker staffing: 2 undergraduate women students in Architecture
Woods and Budwig staffing: 1 MS student in mechanical engineering, 2 MS students in architecture and 1 undergraduate student in Architecture. 2 women.
Maughan staffing: 2 MS students in mechanical engineering, 1 undergraduate student in mechanical engineering
Xing staffing: 1 PhD student in mechanical engineering
Cline, Davis and Morrison staffing: 2 undergraduate students in construction management

5. Description of future plans for project continuation or expansion

- PI Armando McDonald is actively working in wood composites and additive manufacturing. Dr. McDonald was recently awarded a $136K grant from Sun Grant Program Western Region "*Toward production of lignin-based bioplastics and biocomposites*". Also, he was awarded a $200k contract from Idaho National Laboratory "*Characterization of Solvent Extracted Plastics from Municipal Solid Wastes and Alloying to Form Composite Materials*". Drs. McDonald (PI) and Maughan also submitted a preproposal (together with Dr. Maughan, May 2022) to the Department of Defense for $300k titled "Wood-composite structures by additive manufacturing". Drs. McDonald (PI) and Maughan are working on a $650k proposal to USDA-NIFA (planned submission 28 September 2022) on optimization of our current 3D printing system platform.

- CoPI Michael Maughan is actively working in additive manufacturing. Dr. Maughan (PI) was awarded a $3.96 million grant from NSF titled "*RII Track 2 FEC: Developing a Circular Biobased Framework for Architecture, Engineering and Construction Through Additive Manufacturing*". Drs. McDonald and Woods are also senior personnel on this project. This is a multidisciplinary project Between UI and Auburn University. This project has provided the impetus to expand this wood composites additive manufacturing research to include biobased resins and natural fibers. Furthermore, this project includes a rigorous testing program for the AM structures as well as architectural design on how to use AM in construction and built environment.

- CoPI Tao Xing is continuing his work on fluid dynamics and additive manufacturing. He was recently awarded $250k from the M.J. Murdock Charitable Trust for the project "*An Integrated 3D Imaging and Printing System for Studying Biofluid and Biomechanics*". Dr. Xing was also awarded $252k from NSF Major Research Instrumentation for the project "MRI: *Acquisition of a 3D Printer for Studying Biofluids and Biomechanics*". These awards help support our ongoing research activities in additive manufacturing.

- CoPI Damon Woods is continuing his research on thermal/energy behavior in buildings. Drs. Wood (PI) and McDonald (coPI) were awarded $206k in 2021 (plus $106k supplemental in 2022) for an Idaho Department of Commerce IGEM grant titled "*Testing new manufacturing methods of natural fiber insulation batts".* This award helps support research activities in wood/natural fiber composites and construction.

6. Expenditure reports

The expenditure reports presented in Appendix A detail the expenditures at the University of Idaho, including the amounts for paid invoices from Boise State University that totaled $51,257.25.

7. Commercialization Revenue

None to report yet.

Publications:

Orgi, B.O., Thie, C., Baker, K., Maughan, M.R., McDonald, A.G. (2022) Wood fiber - sodium silicate mixtures for additive manufacturing of composite materials. *European Journal of Wood and Wood Products*. DOI: 10.1007/s00107-022-01861-z

Theses:

Tais Mitchell. (2022) Thermal Characterization of Printable Wood Composite and Life Cycle Assessment of a Novel Wood-Based 3D-Printed Exterior Wall. M.S. thesis in Mechanical Engineering, University of Idaho, December 2021, Boise, Idaho.

Conal Thie. (2022) Wood and Resin Composite Extrusion for Additive Manufacturing. M.S. thesis in Mechanical Engineering, University of Idaho , August 2021, Moscow, Idaho.

Robert Carne. (2022) 3D Printing of Wood-Sodium Silicate Composites. M.S. thesis in Mechanical Engineering, University of Idaho, August 2022, Moscow, Idaho.

FWRITEM University of Idaho
Itemized Expenditures by Grant Code
From 01-JUL-2021 To 30-JUN-2022
Grant: RA5551 - ISBOE IGEM 3D Building Print YR3 23-Aug-2022 03:11 PM

Salaries				
E4105 Faculty				
Woods, Lindsay				12096.63
286.04 hours				
Zhang, Wei				1615.60
40.00 hours				
E4106 Staff				
Baker, Kenneth				13760.61
341.20 hours				
E4108 Summer Salary				
Budwig, Ralph				3234.80
2.50 hours				
Maughan, Michael				3195.92
52.00 hours				
Woods, Lindsay				1240.58
29.32 hours				
Xing, Tao				3493.88
52.00 hours				
E4109 IA/GA Salary				
Carne, Robert				16504.80
780.00 hours				
Mitchell, Tais				5920.00
320.00 hours				
Nawafleh, Anas Mohammad Hussein				16497.00
780.00 hours				
Orji, Berlinda Oluebube				20234.24
988.00 hours				
Ramsey, Kelsey				1665.00
90.00 hours				
				$ 99459.06
Temporary/Irregular Help				
E4135 Temporary Student				
Carne, Robert				4441.50
210.00 hours				
Mitchell, Tais				2368.00
128.00 hours				
Nawafleh, Anas Mohammad Hussein				2707.20
128.00 hours				
Sedillo, Joseph				7774.00
428.50 hours				
				$ 17290.70
Fringe Benefits				
E4280 Faculty CFR Benefit Expense				7334.70
E4281 Staff CFR Benefit Expense				5624.51
E4282 Student CFR Fringe Expense				2319.22
				$ 15278.43
Travel				
E5365 Personal Vehicle - Out-of-State				
14-OCT-21	Z1024220	Parking 08062021		36.00
E5371 Motor Pool Vehicle - In-State				
17-AUG-21	Z1021426	A Mcdonald: trip 8718	to pick up wo	35.45
17-MAR-22	Z1031041	A McDonald: trip 9091	Meeting with	57.31

E5372 Motor Pool Vehicle - Out-of-State			
25-FEB-22	J1305132	2-1-22 to 2-15-22 MotPool-arwenb	60.00
E5381 Airfare - Out-of-State			
14-OCT-21	I2201487	McDonald, Armando Gabriel.	448.80
22-MAR-22	Z1031178	Airfare 12132021	336.39
E5392 Ground Transportation-Out-of-State			
22-MAR-22	Z1031178	lyft in LA	34.14
22-MAR-22	Z1031178	lyft in LA area	36.81
E5397 Lodging & Per Diem ? Out of State			
14-OCT-21	Z1024220	McDonald, A: lodging for travel to	995.05
22-MAR-22	Z1031178	Hotel 02272022	188.37
22-MAR-22	Z1031178	hotel expenses (second charge) hote	565.11
22-MAR-22	I2224406	Maughan, Michael	40.00
22-MAR-22	I2224406	Maughan, Michael	74.00
22-MAR-22	I2224406	Maughan, Michael	56.00
22-MAR-22	I2224406	Maughan, Michael	74.00
			$ 3037.43
Operating Expenses			
E5023 Express Mail			
11-NOV-21	Z1025599	McDonald, A: FedEx shipping of samp	11.56
11-NOV-21	Z1025599	McDonald, A: shipping samples for r	26.17
18-JAN-22	Z1028581	McDonald, A: FedEx shipping of rese	11.67
18-JAN-22	Z1028581	McDonald, A: Shipping research samp	16.24
26-JAN-22	Z1028940	McDonald, A: UPS shipping of sample	14.22
E5070 Conference/Registration Fees			
03-SEP-21	Z1022134	McDonald, A: SWST conference regist	650.00
22-MAR-22	I2224406	Maughan, Michael	695.00
E5199 Other Professional Service			
11-OCT-21	J1296434	mech engr shop chrgs 3d prntr wrk	341.00
E5320 Software/Applications - Individual			
28-JUL-21	J1292993	CT 500.01 from 849997 to 849989	500.01
04-NOV-21	TC102721	TDX190117 Adobe Acrobat Pro 2020	107.88
04-NOV-21	TC102721	TDX190117 Microsoft Visio Prof.	33.94
04-NOV-21	TC102721	TDX191661 Adobe Acrobat Pro 2020	107.27
04-NOV-21	TC102721	TDX191661 Microsoft Visio	33.94
E5350 Other Technical Services			
23-SEP-21	J1296645	DDE/CT from 849997	1050.00
03-MAR-22	J1305423	DDE/CER Basham Lab Services	2400.00
23-MAY-22	J1310305	SB; Basham Hrs CER Lab Services	525.00
E5410 Office and Administrative Supplies			
23-SEP-21	Z1023283	Doorstops IDL labs	9.99
E5724 Research Supplies			
06-AUG-21	J1292558	machine shop chrgs for IGEM prntr	120.00
06-AUG-21	J1292557	machine shop work for MechEngr	194.00
03-SEP-21	Z1022134	McDonald, A: Bipee round cover slip	9.80
03-SEP-21	Z1022134	McDonald, A: Sodium silicate for re	48.34
03-SEP-21	Z1022134	McDonald, A: conductive adhesive ta	43.10
03-SEP-21	Z1022134	McDonald, A: refund from shipping c	-24.22
10-SEP-21	Z1022370	Calibration Materials ordered for I	78.46
20-SEP-21	Z1022903	McDonald, A: DSC aluminum sample pa	476.81
20-SEP-21	Z1022903	McDonald, A: Sodium silicate soluti	111.36
22-SEP-21	Z1023158	Expense for a breadboard (DIY circu	6.99
22-SEP-21	Z1023158	Expense for a few resistors so that	9.63
28-OCT-21	Z1024848	Purchase Tecplot for research. Inde	1156.66
01-NOV-21	Z1024941	Purpose: Steel tubing necessary for	73.52
01-NOV-21	Z1024941	Purpose: Supplies for heat exchange	42.64
11-NOV-21	Z1025599	McDonald, A: chemicals for research	45.81
11-NOV-21	Z1025599	McDonald, A: chemicals for research	35.73
01-DEC-21	J1300511	JKD/ Phys Shp Wrk: McDonald	543.50

10-DEC-21	Z1027024	McDonald, A: DSC pans for research.	480.52
10-DEC-21	Z1027024	McDonald, A: DSC pans for research.	189.40
10-DEC-21	Z1027024	McDonald, A: Duracell batteries for	10.97
10-DEC-21	Z1027024	McDonald, A: Extruder parts for res	2556.53
10-DEC-21	Z1027024	McDonald, A: Flat steel bar for res	12.08
10-DEC-21	Z1027024	McDonald, A: Replacement O-Rings fo	7.25
10-DEC-21	Z1027024	McDonald, A: Submersible water pump	13.99
10-DEC-21	Z1027024	McDonald, A: Ziplock bags for resea	8.51
10-DEC-21	Z1027024	McDonald, A: replacement food proce	28.62
10-DEC-21	Z1027024	McDonald, A: saw blade for table sa	17.13
10-DEC-21	Z1027024	McDonald, A: table saw for research	377.10
29-DEC-21	Z1027787	grains to build wood 3D printer ind	10.59
29-DEC-21	Z1027787	supplies to build wood 3D printer i	3.78
18-JAN-22	Z1028581	McDonald, A: 21X datalogger for res	53.00
18-JAN-22	Z1028581	McDonald, A: 21X datalogger refund	-53.00
18-JAN-22	Z1028581	McDonald, A: Batteries for research	12.74
18-JAN-22	Z1028581	McDonald, A: Brushes for research.	22.67
18-JAN-22	Z1028581	McDonald, A: Campbell Scientific CE	51.24
18-JAN-22	Z1028581	McDonald, A: Durometer for research	28.00
18-JAN-22	Z1028581	McDonald, A: Lab supplies: Buchner	47.97
18-JAN-22	Z1028581	McDonald, A: Lap supplies: 9 count	23.62
18-JAN-22	Z1028581	McDonald, A: Thermogravimetric unit	624.13
03-FEB-22	Z1029276	Parts for constructing 3D weaver ma	854.96
03-FEB-22	Z1029276	Parts for constructing 3D weaver ma	945.24
03-FEB-22	Z1029326	PLA Filament puchased for research	31.48
03-FEB-22	Z1029336	Purpose: bearings to build wood 3d	433.91
03-FEB-22	Z1029336	Purpose: padlock eyes to secure mat	62.24
03-FEB-22	Z1029336	Purpose: padlocks to secure equipme	51.36
03-FEB-22	Z1029336	Purpose: tools to build the wood 3d	61.73
03-FEB-22	Z1029336	linear motion shaft: Purpose: suppl	139.69
17-FEB-22	Z1029869	Purpose: Supplies build wood 3D pri	37.98
17-FEB-22	Z1029869	Purpose: Supplies to build wood 3D	27.06
17-FEB-22	Z1029869	Purpose: VFD for new extruder neces	348.29
17-FEB-22	Z1029869	flat bar Purpose: metal to build wo	17.60
17-FEB-22	Z1029869	heat shrink butt connectors kit Pur	15.99
17-FEB-22	Z1029869	tools and supplies for research lab	264.97
17-FEB-22	Z1029869	tools and supplies for research lab	210.94
17-FEB-22	Z1029869	tools and supplies for research lab	190.62
28-FEB-22	Z1030257	Keyboards purchased for use with la	26.97
24-MAR-22	Z1031286	Parts for constructing 3D weaver. I	112.28
30-MAR-22	Z1031591	HERC-IGEM purchases. I went to Home	12.99
30-MAR-22	Z1031591	HERC-IGEM purchases. I went to Home	7.99
30-MAR-22	Z1031591	HERC-IGEM purchases. I went to Home	19.92
30-MAR-22	Z1031591	HERC-IGEM purchases. I went to Home	49.51
30-MAR-22	Z1031618	Mcdonald, A; Ridgeyard Manual Sugar	256.99
06-APR-22	Z1031921	From Cardholder E-mail: A receipt	47.40
12-APR-22	J1307690	JKD/ Phys Shp Wrk: McDonald	365.00
14-APR-22	Z1032353	691636 ? Supplies to build wood 3D	10.27
14-APR-22	Z1032353	691636 ? Supplies to build wood 3D	41.01
14-APR-22	Z1032353	691636 ? Supplies to build wood 3D	1564.36
14-APR-22	Z1032353	electric linear actuator - then ful	44.19
14-APR-22	Z1032353	filament, 691636 ? Supplies to buil	69.97
14-APR-22	Z1032353	full refund for 44.19 expense 69163	-44.19
14-APR-22	Z1032353	fully refunded 3d printer supplies	-1564.36
14-APR-22	Z1032353	shrink tubing, stepper motor 691636	96.95
15-APR-22	Z1032416	Mcdonald, A; 4-port USB 3.0 purchas	15.99
15-APR-22	Z1032416	Mcdonald, A; Fielect 24V Brushless	11.84
15-APR-22	Z1032416	Mcdonald, A; Pipe fittings and meta	41.30
25-APR-22	Z1032930	mounting brackets Purpose: supplies	8.85
25-APR-22	Z1032930	semiconductors, diodes, etc Researc	23.31

17-MAY-22	Z1034317	Mcdonald, A; 8oz Gorilla Glue purch	12.49
17-MAY-22	Z1034317	Mcdonald, A; Book on wood adhesives	28.30
17-MAY-22	Z1034317	Mcdonald, A; Electrical connectors	10.92
17-MAY-22	Z1034317	Mcdonald, A; Lab supplies purchased	22.25
17-MAY-22	Z1034317	Mcdonald, A; Panel outlets purchase	8.99
17-MAY-22	Z1034317	Mcdonald, A; Pipette bulb filler fo	14.18
17-MAY-22	Z1034317	Mcdonald, A; Switches purchased for	7.99
17-MAY-22	Z1034317	Mcdonald, A; Thermocouple plug purc	31.30
17-MAY-22	Z1034317	Mcdonald, A; Unit instruments UFC-1	32.49
06-JUN-22	Z1035606	o Research supplies this is a micro	380.00
06-JUN-22	Z1035606	o Research supplies. A radiator to	38.99
06-JUN-22	Z1035606	o Research supplies. Bearings to re	10.50
06-JUN-22	Z1035606	o Research supplies. Bearings to re	12.99
06-JUN-22	Z1035606	o Research supplies. Hose connector	131.00
17-JUN-22	Z1036922	McDonald, A; Fuses purchased for us	19.30
17-JUN-22	Z1036922	McDonald, A; Spigots purchased for	17.98
17-JUN-22	Z1036922	Mcdonald, A; Connectors purchased f	12.99
E5741 Med Lab & Tech Supplies			
10-NOV-21	J1299491	jkm/ct from 691678 to 691649	18.35
11-FEB-22	U0139717	Chemstores/McDonald	119.06
17-MAY-22	U0140367	Chemstores/MaDonald	45.68
			$ 19921.21
Subawards			
ES001 Subaward 1 Expenses			
02-APR-22	I2226130	Boise State University	21664.32
25-MAY-22	I2235209	Boise State University	2348.67
16-JUN-22	I2239086	Boise State University	27244.26
			$ 51257.25
Tuition Remission and Training			
E7140 Tuition and Fees - Grad Assistants			
09-AUG-21	J1293588	G1GB for V00705715	786.00
09-AUG-21	J1293588	SHI1 for V00705715	978.00
13-AUG-21	J1293884	G1GA for 181-71260	786.00
13-AUG-21	J1293884	SHI1 for 181-71260	978.00
13-AUG-21	J1293884	T1GA for 181-71260	4170.00
17-AUG-21	J1294016	G1GC for V00467497	786.00
17-AUG-21	J1294016	G1GC for V00758485	786.00
17-AUG-21	J1294016	JBB1 for V00467497	105.00
17-AUG-21	J1294016	RAP1 for V00467497	695.00
17-AUG-21	J1294016	T1GC for V00467497	4170.00
17-AUG-21	J1294016	T1GC for V00758485	4170.00
20-AUG-21	J1294344	bb move from 819989	4170.00
23-AUG-21	J1293645	G1GB for 172-63620	786.00
23-AUG-21	J1293645	SHI1 for 172-63620	978.00
23-AUG-21	J1293645	T1GB for 172-63620	4170.00
23-AUG-21	J1293645	VVSF for 172-63620	100.00
07-SEP-21	J1294874	ID1C for 172-63620	175.00
03-JAN-22	J1301695	G2GB for 172-63620	786.00
03-JAN-22	J1301695	T2GB for 172-63620	4170.00
03-JAN-22	J1301695	VVSF for 172-63620	100.00
05-JAN-22	J1301967	G2HC for V00788801	522.00
05-JAN-22	J1301967	RAG2 for V00788801	462.00
05-JAN-22	J1301967	T2HC for V00788801	2772.00
06-JAN-22	J1302117	G2GA for 181-71260	786.00
06-JAN-22	J1302117	SHI2 for 181-71260	978.00
06-JAN-22	J1302117	T2GA for 181-71260	4170.00
01-FEB-22	J1302114	G2GB for V00705715	786.00
01-FEB-22	J1302114	SHI2 for V00705715	978.00

01-FEB-22	J1302114	T2GB for V00705715	4170.00
04-APR-22	J1307150	JAB2 for V00788801	105.00
01-MAY-22	J1308750	JBB2 for V00788801	105.00
19-MAY-22	J1309824	G3HB for 172-63620	87.00
19-MAY-22	J1309824	MP3 for 172-63620	35.00
19-MAY-22	J1309824	T3HB for 172-63620	462.00
14-JUN-22	J1312128	dls; refund V00618943	-35.00
			50228.00
		Total Expenses	$ 256472.08

FWRITEM University of Idaho
Itemized Expenditures by Grant Code
From 01-JUL-2021 To 30-JUN-2022
Grant: RA5551 - ISBOE IGEM 3D Building Print YR3 23-Aug-2022 03:11 PM

Salaries	
E4105 Faculty	
Woods, Lindsay	12096.63
286.04 hours	
Zhang, Wei	1615.60
40.00 hours	
E4106 Staff	
Baker, Kenneth	13760.61
341.20 hours	
E4108 Summer Salary	
Budwig, Ralph	3234.80
2.50 hours	
Maughan, Michael	3195.92
52.00 hours	
Woods, Lindsay	1240.58
29.32 hours	
Xing, Tao	3493.88
52.00 hours	
E4109 IA/GA Salary	
Carne, Robert	16504.80
780.00 hours	
Mitchell, Tais	5920.00
320.00 hours	
Nawafleh, Anas Mohammad Hussein	16497.00
780.00 hours	
Orji, Berlinda Oluebube	20234.24
988.00 hours	
Ramsey, Kelsey	1665.00
90.00 hours	
	$ 99459.06
Temporary/Irregular Help	
E4135 Temporary Student	
Carne, Robert	4441.50
210.00 hours	
Mitchell, Tais	2368.00
128.00 hours	
Nawafleh, Anas Mohammad Hussein	2707.20
128.00 hours	
Sedillo, Joseph	7774.00
428.50 hours	
	$ 17290.70
Fringe Benefits	
E4280 Faculty CFR Benefit Expense	7334.70
E4281 Staff CFR Benefit Expense	5624.51
E4282 Student CFR Fringe Expense	2319.22
	$ 15278.43
Travel	
E5365 Personal Vehicle - Out-of-State	
E5371 Motor Pool Vehicle - In-State	
E5372 Motor Pool Vehicle - Out-of-State	
E5381 Airfare - Out-of-State	
E5392 Ground Transportation-Out-of-State	

E5397 Lodging & Per Diem ? Out of State	
	$ 3037.43
Operating Expenses	
E5023 Express Mail	
E5070 Conference/Registration Fees	
E5199 Other Professional Service	
E5320 Software/Applications - Individual	
E5350 Other Technical Services	
E5410 Office and Administrative Supplies	
E5724 Research Supplies	
E5741 Med Lab & Tech Supplies	
	$ 19921.21
Subawards	
ES001 Subaward 1 Expenses	
	$ 51257.25
Tuition Remission and Training	
E7140 Tuition and Fees - Grad Assistants	
	$ 50228.00
Total Expenses	$ 256472.08

Progress Report for IGEM 22-001

The Cyberdome — An Investment in Idaho's Cybersecurity Future

1st July 2021 – 30th June 2022

Year One Full-year Progress Report

BOISE STATE UNIVERSITY

IGEM 22-001

The Cyberdome — An Investment in Idaho's Cybersecurity Future

1st July 2021 – 30th June 2022, Year One Full-year Progress Report

Table of Contents

IGEM 22-01: The Cyberdome –
An Investment in Idaho's Cybersecurity Future
1st July 2021 – 30th June 2022, Year One Full-year Progress Report

Project Summary

The Idaho Global Entrepreneurial Mission (IGEM) and State Board of Education Higher Education Research Council (HERC) have provided the first year of funding to the Institute for Pervasive Cybersecurity (IPC) at Boise State University to build and establish the **Cyberdome** – a Security as a Service (SECaaS) oriented platform meant to leverage force-multiplying efforts of our students to secure critical cyber/physical assets of rural and remote clients.

The IPC is pleased to inform HERC that the project continues on track and within budget against the timeline below. **Figure 1** below shows the relevant view of the timeline provided during award discussions. This has been used to track our progress towards success.

Year 1: FY'2022	July	August	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Task												
Create platform												
Hire Cyberdome Management Team / Grad Assistants	x	x										
Establish cloud environment (AWS)		x	x									
Set up cloud systems and service architecture		x	x									
Activate technical workflows			x	x	x							
Milestone: Cloud Services Activated					1-Nov							
Initiate hiring of student workers			x	x								
Milestone: Initial student team hired				31-Oct								
Training for Cohort 1 team												
Develop training		x	x									
Deliver training sessions				x	x							
Milestone: Cohort 1 activated and trained					15-Nov							
Cohort 1 workers					x	x	x	x	x	x	x	
Outreach to "Round 1" SLTT clients		x	x	x								
Activation of "Round 1" SLTT clients					x	x	x					
Milestone: Activation of first Cyberdome SLTT client							1-Jan					
Active Monitoring of SLTT clients initiated							x	x	x	x	x	x
Student Cohort Hiring									x	x	x	
Deliver training sessions										x	x	
Milestone: Next student cohort hired and activated											15-May	
Cohort 2 workers											x	x
Research initiation: Cloud Security Architecture								x	x	x	x	x
Research initiation: Threat Analytics								x	x	x	x	x
Research initiation: Critical infrastructure Analysis								x	x	x	x	x
Reserch Initiation: Dark web / social media analysis								x	x	x	x	x
Outreach to "Round 2" SLTT clients										x	x	x

Figure 1. July to June view of Cyberdome timeline

This progress report summarizes the activities during the project's first twelve (12) months. Please note: Objective #1 from our proposal continued to be the primary focus this first full-year period. The other objectives will be balanced in future reporting periods now that the platform is built, operational, and has the expected number of clients per our goals.

Project Accomplishments

The Cyberdome proposal identified three primary objectives:

1. ***Create competency-based learning platforms for Idaho cybersecurity learners***
2. ***Reduce critical cybersecurity risks for State, Local, Tribal, and Territorial (SLTT) clients***
3. ***Produce innovative research, tools, and techniques to transfer to commercial efforts***

Progress to date toward implementing these strategies is detailed in the following subsections.

Objective One: Create competency-based learning platforms for Idaho cybersecurity learners

Following receipt of funding in July 2021, the IPC successfully hired its two full-time staff members in August and September, respectively. Each team member comes with over a decade of technology industry experience, enabling each to provide direct mentorship to our undergraduate students & graduate assistants assigned to building the platform. Further, three (3) graduate assistants were enabled in the August and September timeframe. The delayed hiring/enablement of these staff members and graduate assistants did not impact the overall activation timeline.

Undergraduate student hiring has been ongoing against the general timeline provided above as well. A more concise hiring timeline across all roles is provided below in **Figure 2**.

Job Title	August 2021	September 2021	October 2021	November 2021	December 2021	February 2022	March 2022	May 2022	Grand Total
Analyst	1		4	1	2	8	2	7	25
Cyberdome Mgr		1							1
Engineer	2	2	1			4		2	11
Graduate Asst	3							1	4
Lead Analyst								1	1
Lead Engineer	1								1
Total	**7**	**3**	**5**	**1**	**2**	**12**	**2**	**11**	**43**

Figure 2. Hiring timeline by month over the reporting period

Recruiting, Hiring, and Training Processes

General Recruitment

Via the statewide cybersecurity program, the Cyberdome staff leveraged peer contacts throughout Idaho and worked to build connections to bolster recruitment and hiring efforts for Analysts and Engineers. A goal of the team continues to be enabling students from all eight public higher education institutions across Idaho to participate. As shown in **Figure 1**, the team's grant proposal timeline suggested the Institute would hire a full cohort of 14 interns and have them trained and ready to activate by mid-November. Throughout this period, the Cyberdome team faced several unexpected challenges that impacted the ability to recruit and fill these roles:

- The initial assumption that leadership would be able to find a Manager to lead the platform recruiting and training efforts by July 2021 was not met. Instead, the Cyberdome Manager started in early September 2021, which effectively pushed back the platform's development timeline by a full two months.
- The initial budget proposed each student would be hired at a wage of $12.50 per hour. The Cyberdome leadership team had very little success recruiting at this wage rate due to inflationary market impacts that started in 2021 and have continued since. Feedback from staff and faculty of academic programs indicated that the job market and inflation had rapidly increased the rate interns could command. One Computer Science program staff member commented that their program now pays even their most inexperienced interns $14.00 per hour. This proved to be true as a super-majority of early Cyberdome internship applicants were in their sophomore and junior years with limited knowledge developed through coursework or work experience.
- It took the Cyberdome team time to build connections with staff and faculty outside Boise State University to enable internship marketing and outreach efforts. This effort continues as other institutions face staff/instructor turnover.
- The team discovered a "direct pathway" challenge between four-year institution students vs students choosing a pathway from a community college. "Direct pathway" students have a significant gap in applied areas of technical knowledge. In particular, "direct pathway" students have not been equipped with the skillset of a strong foundation in TCP/IP networking. Such a foundation is critical to success as an early-stage Cybersecurity Engineer or Analyst. A critical lack of appropriate networking curriculum at four-year institutions impacts student success as operational cybersecurity professionals. In April 2022, the Cyberdome's most recent round of Analyst recruiting, only 30% (six out of twenty students) of "direct pathway" students from four-year institutions demonstrated the networking skill sets needed to merit a 2nd interview opportunity. This curriculum gap is one to be addressed via the statewide cybersecurity curriculum development efforts.

As a result of these challenges, the team hired and trained ten student interns before the expected start of Cohort 1 in mid-November. The profile of all interns hired to date is different than initially anticipated. The Cyberdome team anticipated hiring students who were in their final year of their associate's or bachelor's degree and wanted a capstone experience before graduation. Instead, many

early hires were juniors and even first-year graduate students searching for internships they could engage with early in their studies. As a result, comprehensive post-internship hiring metrics are not yet available. Two interns in the first cohort were in/near their final semesters and have reported being hired at well above average market salary levels. The first intern was a BS graduate of Boise State's computer science program and was involved in the development of our virtual city portal. The student was hired in the local market as a programmer at a base salary of $105,000. The second intern graduated a semester after completing their Cyberdome internship with a BS in computer science w/cybersecurity emphasis. They were subsequently hired in the local market by an international company into a security engineer role at a base salary of $100,000.

Additionally, starting in February 2022, Cyberdome staff made the decision that they must increase student wages to attract students with a class standing and depth of knowledge commensurate with initial expectations. Analysts now earn $15.25 per hour and Engineer wages start at $16.00 per hour. This change made a meaningful difference as 96% of our current interns are expected to graduate within 12 months and 68% are within 7 months of graduating. This has also impacted our go-forward budgets and the expected number of Cyberdome graduates. At this point, barring any further inflationary pressures, the Cybedome team expects to reduce the number of supported students to 23 from the original 28 supported students in the grant proposal. Doing so will not require a budget impact to the original funding request. While the number of students per cohort will decrease, the anticipated ROI and economic impact is expected to remain the same. This is due to the base / premium salary increases occurring for entry-level cybersecurity roles.

The Cyberdome team has worked quickly to catch up on hiring and currently employs 25 interns including 16 Analysts and 9 Engineers. This includes active interns from six of Idaho's eight public higher education institutions with Boise State University, College of Eastern Idaho, College of Southern Idaho, College of Western Idaho, Idaho State University, and Lewis-Clark State College all represented. A graduate student from the University of Idaho is expected to join the program in August 2022.

Analyst Recruiting

July 2021 - December 2021

The Cyberdome team recruited eight Cybersecurity Analyst workers between August and December. This initial cohort completed initial assessments, and individualized training, and then provided significant feedback as to the quality and relevance of the training for future enhancements. Changes from this feedback were then incorporated into the training to provide a quality experience for subsequent cohorts.

The initial cohort of analyst interns was composed of students from the Boise metropolitan area as well as rural Idaho locations. Students were recruited from the Twin Falls and Lewiston/Clarkston areas, connecting remotely. The final composition of the cohort was five Boise-local students and three remote students. The cohort consisted solely of Boise State students.

January 2022 - June 2022

The second cohort of Cybersecurity Analysts was recruited through two waves of hiring. The first wave consists of ten analysts hired between February and March. The second wave was recruited in May and consists of seven analysts. One analyst from the February to March cohort was removed from the program after three weeks due to not showing up for shifts.

The Cyberdome team increased outreach to statewide public institutions other than the Boise area during this timeframe. Substantial effort was made to identify key faculty and administrators at the other public institutions, and contacts were made. A student-oriented presentation was developed and given to students in classes that were either Cybersecurity specific, or closely related (e.g., Computer Science). This resulted in greater institutional diversity in the second cohort of Analysts. The breakdown of contributions from each institution is given in **Chart 1**.

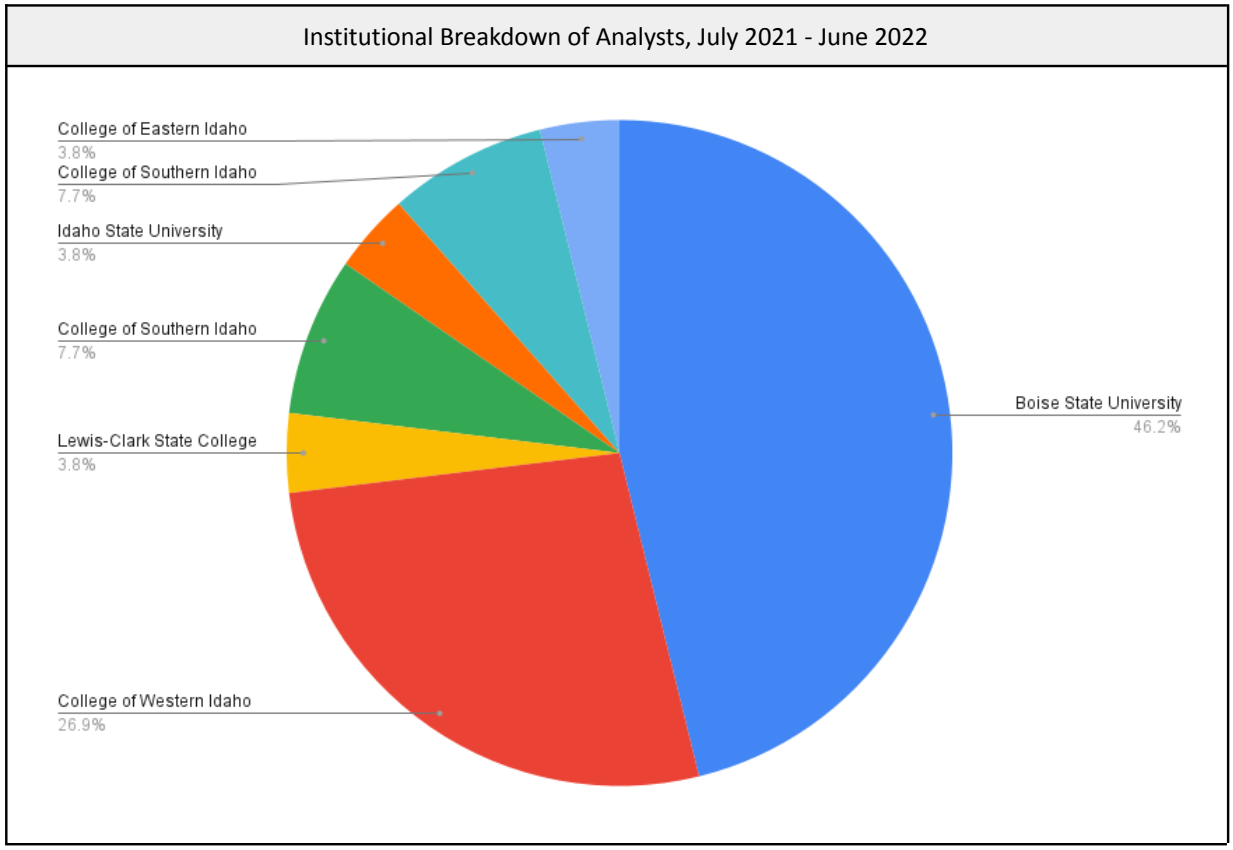


Chart 1. Analysts Hiring by Institution over Reporting Period

Engineer Recruiting

Engineer recruiting efforts included posting on institutional job sites, as well as identifying analyst candidates that had skills appropriate for the engineering position. Also, both roles were presented to students as part of the classroom recruitment efforts. Students considered for the engineering position typically had stronger applied technology experience (e.g. prior networking or integration experience). During the initial startup of the Cyberdome, most engineering tasks required an on-site presence. Owing to this, between July 2021 and December 2021 the initial round of recruited engineers was from Boise State University. After the initial on-site tasks were completed, the recruiting expanded to include remote candidates. The final institutional breakdown of engineers is given in **Chart 2**.

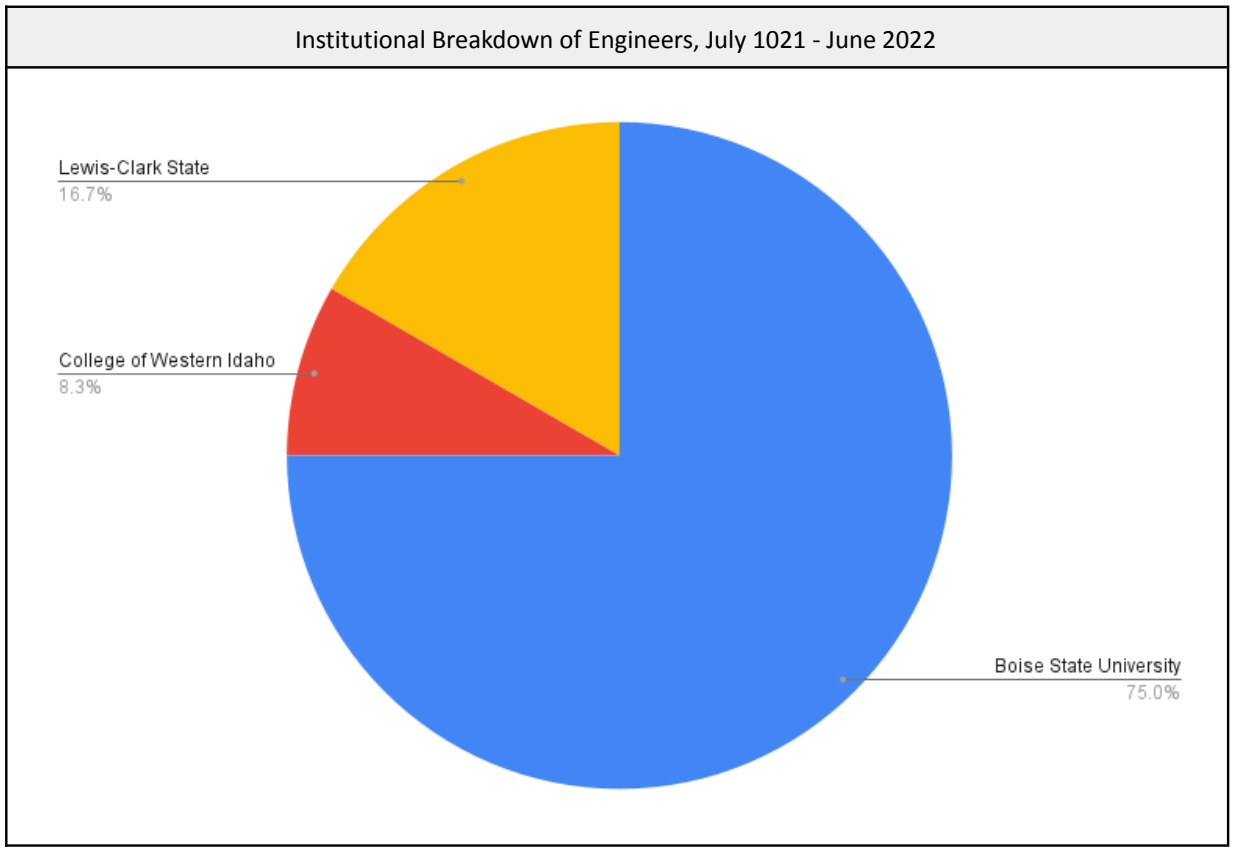


Chart 2. Engineer Hiring by Institution over Reporting Period

Key Technical Partnerships & Economic Development

Upon initial funding, the Cyberdome team intended to utilize SecurityOnion as our core production monitoring platform. This aligned with both our simulation environment and the statewide cybersecurity efforts to build out the Idaho Cyber Range. SecurityOnion training had been provided during the first year funding cycle of the statewide initiative and aligning to this platform was intended to strengthen the objectives and goals of both the statewide effort and the Cyberdome. Unfortunately, it was discovered that the SecurityOnion platform is not fully "multi-tenant" (e.g., able to securely separate multiple clients' logs and monitoring information) and would therefore not meet the goals of the second Cyberdome objective to "Reduce critical cybersecurity risks for SLTT clients." While this finding may have presented a terminal problem to this program, instead, a search was undertaken to find a commercial partner that could meet the stated objectives of the Cyberdome.

The Cyberdome team was able to connect, and subsequently partner, with Stellar Cyber, a recognized leader in the Open eXtended Detection and Response (OpenXDR) community. The Stellar Cyber executive team entered into a memo of understanding (MOU) with Boise State to provide gratis licensing, support, and training to Cyberdome interns. As well, they enabled outreach to an extensive partner community that is actively looking to hire Cyberdome interns. The Cyberdome graduate students, along with the Lead Engineer, undertook the effort of switching the core platform to Stellar Cyber, thereby providing multi-tenancy for SLTT clients, before our critical launch date.

In addition to Stellar Cyber, two other technology partners have stepped forward to provide gratis licensing to their commercial products. One company, PlexTrac, is headquartered in Boise and has recently raised over $80M to support its growth and go-to-market strategies. Through an MOU, PlexTrac has enabled the Cyberdome to leverage its reporting platform to enhance our client experiences and metric presentation. Our graduate assistants and undergraduate interns are in the process of integrating the PlexTrac platform with Stellar Cyber and expect to have this completed within the 2nd year reporting period. Further, PlexTrac and the IPC have internship and hiring pathways enabled for a wider audience of students.

The third technology partner is HYCU. The partnership MOU enables the Cyberdome to utilize HYCU's R-Score ransomware scoring platform. This platform enables our interns to work directly with our SLTT clients on determining key governance and risk metrics for future tracking and reporting purposes.

Where appropriate, these technology partners have enabled training for our interns, along with platform certification opportunities as part of their respective MOUs.

Beyond these initial technology partners, PI Vasko is in discussions with key national cybersecurity partners to enable further technology integrations for our SLTT clients, as well as applied learning

opportunities for our interns. Further, PI Vasko is engaging with national Managed Security Service Providers (MSSPs) to communicate Idaho's cybersecurity workforce development efforts via the Cyberdome. These efforts have resulted in local & national media outlets covering the story of the Cyberdome and its objectives. A summary list of coverage is provided below:

- KIVI News 6 (Local): https://www.youtube.com/watch?v=Eo8_jwQII6k
- KTVB (Local): https://www.ktvb.com/article/news/local/boise-state-cyberdome-program-bolsters-rural-cybersecurity/277-ee67d2f3-7b85-4572-907b-e9a309b65720
- Geekwire (National): https://www.geekwire.com/2022/boise-state-universitys-new-cybersecurity-program-helps-train-workers-and-protect-rural-communities/
- EdScoop (National): https://edscoop.com/boise-state-welcome-to-the-cyberdome/

Cyberdome Knowledge and Skill Assessment / Training Enhancement Program

The key objective of workforce development is accomplished by hiring, training and developing student workers in the roles of Cybersecurity Analyst and Cybersecurity Engineer. To this end, the Cyberdome team leveraged the educational background and experience of a graduate assistant as well as the industry experience of the Cyberdome Manager to create a comprehensive training program built around available cybersecurity resources.

To ensure that the training program fully aligned with industry expectations, an analysis was conducted of the cybersecurity industry roles specified at the National Initiative of Cybersecurity Careers and Studies (NICCS). These roles are defined in the NICE framework developed by NIST. In particular, the roles of Cyber Defense Analyst and Cyber Defense Infrastructure Support Specialist were identified as being highly aligned with the goals of the Cyberdome project. Since the roles defined in the NICE framework are competency-based, the objective of making a competency-based learning platform is strongly realized through this.

Once industry roles were identified, the knowledge, skills, and abilities (KSAs) defined for each role were utilized to create a KSA assessment tool for both pre and post-evaluation of the participants. This assessment tool uses both self and peer evaluation methods to determine a baseline skill set as well as determine what progress a participant has made towards being a workforce-ready graduate.

Leveraging statewide cybersecurity collaboration efforts and this assessment tool, prospective students from around Idaho can now provide a list of courses taken at any public institution and the Cyberdome management team can produce a knowledge and skill gap assessment for each worker. Utilizing this output, proscriptive training support is enabled for workers before they engage in production monitoring activities. As our college and university partners further build and enhance their respective cybersecurity curricula, the assessment tool will continue to be updated. Further, this tool is being

examined for possible technology transference. In future funding years, the Cyberdome team intends to provide a report to each participating institution on knowledge and skill gaps identified so potential curriculum enhancements can be made.

Initial assessments were conducted on the first cohort of workers. These initial assessments provided a baseline from which further training was developed to close the gap between actual and desired competencies. Training content was organized into a comprehensive course shell housed in Boise State's learning management system. This allows the IPC to provide training remotely, track student progress and selectively expose training modules based on the determined knowledge and skills of a participant.

Training content covers a variety of areas related to the determined roles:

- General Cybersecurity concepts
- Networking concepts and practical networking tools
- Common attack types and attributes
- Cybersecurity defense principles
- Platform-specific programs and tools

For previously discussed reasons, the Cyberdome team shifted to utilizing a commercial product via our partner, Stellar Cyber. The use of Security Onion is ongoing within our training/simulation platform (e.g., Boise State's connection to the Idaho Cyber Range). Training on the individual components of the platform was obtained from several sources and enables our students to engage in multiple open-source/commercial platforms as a result of their engagement in the Cyberdome.

Graduate Assistant Contributions

The three graduate assistants assigned to the IPC have experience and backgrounds in computer science and education, as well as practical experience using Amazon Web Services (AWS). These backgrounds aligned well with the immediate needs of the IPC in the development of training and deploying the cyber security platform to the cloud.

The graduate assistants assisted in establishing the AWS environment, which included setting up identity and access management, security settings, and all related virtual machines for operating the Cyberdome. They also gained critical experience in creating Amazon Machine Images (AMIs) from base operating system images to facilitate the development of the final software environment, which consisted of pfSense, Security Onion, Stellar Cyber, and different Linux virtual machines.

At the beginning of 2022, the Cyberdome switched its primary security software from Security Onion to Stellar Cyber. Using Stellar Cyber's software upgraded the Cyberdome with multi-tenant access through a single web interface, integrated threat hunting tools, response features (e.g., upgraded our SIEM to

have Security Orchestration & Automated Response [SOAR] capabilities), and easily configurable forward deployment sensor hardware and software (e.g., what used to take up to two-days to configure now takes less than an hour). By contrast, Security Onion required a separate interface per tenant (and would have increased costs as a result), demanded more costly equipment to achieve the same functionality, and lacked other key functionality like SOAR. Additionally, the graduate assistants were able to demonstrate API access to stored data using Stellar Cyber's published API set. The Stellar Cyber REST API makes academic data analysis much more streamlined than using Security Onion.

Extensive work was performed on analyzing and securing cloud access mechanisms and establishing role-based access control models. A sophisticated virtual private network (VPN) was deployed to provide secure access to the cloud resources. This was accomplished with open source software (OpenVPN) and includes encrypted access to resources, restricted port access, and multi-factor authentication (MFA) for additional security. The VPN allows both Cyberdome engineers and analysts to access the full cyber security platform from any location, enabling remote work across the state. A VPN is also used to provide secure site-to-site connectivity to client on-premise monitoring hardware.

The graduate assistants researched and documented the underlying data stores in the security platform. These data stores contain the collected data from Cyberdome clients and include event logs and signature analysis of packet data. The graduate assistants are now actively designing a data warehouse that will be deployed to maintain this data for research purposes in future funding reports.

Cyberdome Engineer Contributions

The Cyberdome started with four (4) student workers in the role of Cyber Security Engineer. Starting in February 2022 the number of engineers increased to nine (9). Engineer skill sets included computer science, networking, computer, and electrical engineering. The engineers were tasked with the development of supporting systems, deployment of test systems, and creating virtual test environments.

The engineers' first key task was the creation of an extensive virtual simulation environment that enables analyst skill development. The training environment is composed of common technical services that might be found in a typical city. This Virtual City is now being utilized as a training testbed and contains elements found in storefronts, utilities, and SLTT environments. This test facility provides a complete, isolated sandbox for security exercises and research. The engineers gained valuable skills in networking such as establishing a provider network, local area networking, bridging, switching, routing, and setting up VPNs. Additionally, they developed skills in virtualization technologies such as securely configuring virtual clusters, and automating the creation and destruction of virtual machines. All of these skills are directly applicable to their chosen cyber engineer careers and also enabled a deeper understanding of core cybersecurity principles.

Between July and December 2021, a group of engineers and senior computer science students built a tool for configuring appliances in the Virtual City, called the Virtual City Web Controller. This tool allows for the automated creation of accounts for student access to the Virtual City. The tool is capable of starting virtual machine instances within the Virtual City using predetermined scenarios. This allows for the rapid configuration of the Virtual City for use in expanded training and collaboration. This tool provides the basis for being able to quickly and efficiently instantiate virtual scenarios such as a compromised office, or create multiple environments on the same provider network.

Before switching to Stellar Cyber's commercial sensor, the engineering team researched and developed a configuration for the on-premise technologies (a "sensor") to be deployed at client sites. The sensor acts as the central hub that collects data from client systems and networks, and sends logs and parsed signatures to the security platform in the cloud. A version of the sensor was developed and deployed inside the Virtual City as a prototype before attempting to build a production version on a stand-alone server. The sensor is a complex combination of virtualized systems housed in one physical device. These include a VPN for security, port rerouting for external access, multiple virtual machines for sensing, processing, and shipping of data, and finally vulnerability scanning tools for investigating alerts. Several prototypes of the sensor were developed before a suitable model was created. Ultimately one was deployed to monitor the Virtual City itself. This deployment has the added benefit of creating test data for Cyberdome analysts for use in training. This sensor serves as a prototype for all subsequent sensors built for actual Cyberdome clients.

Several engineers developed a penetration testing plan for use against both Cyberdome assets and possible client environments. The key goal of this is to ensure assets are monitored, tested, and secure. This plan used industry-standard tools and was tested against the Virtual City and the model client sensor to validate the plan's usefulness while also hardening Cyberdome assets. This plan served as a training vehicle for current students and will be used to train future cohorts as they execute and update the current plan. This has the added benefit of also continuously improving the Cyberdome's security posture. Penetration testing techniques are a fundamental part of a cyber professional's tool kit, and this experience is directly applicable to the future careers of engineers and analysts. Additionally, this work provides the basis for developing a similar strategy for testing Cyberdome clients, as well as improving our risk assessment procedures.

Engineers configured a suite of assets with open source vulnerability scanning tools. These systems can be used to scan in-house assets as well for conducting risk assessments with actual clients. It also provided the students with hands-on training on how to set up a penetration testing and vulnerability scanning platform. Kali Linux was used as the base operating system as this is a common platform used in the security industry.

The requirements and foundational code base for a Cyberdome Client Web Portal were created. The portal is capable of summarizing security operations and controlling events and alerts, while also providing clients a portal for managing their team's access. This project will provide further training for

a new cohort of engineers as they develop the project, and may also lead to technology transfer opportunities.

A self-contained, mobile network lab was developed and demonstrated for outward recruiting and education. The lab consisted of a managed switch, WiFi Router, and fifteen Raspberry Pi[1] computers. The hands-on workshop showcased ad-blocking, Internet detection, and basic penetration testing techniques. Through the workshop, basic networking concepts (which would be implemented in a home or small workplace environment) were explained and demonstrated to non-technical audiences. The mobile lab is completely self-contained so that when penetration testing is performed no access to the outside world was possible. The mobile network lab was first used at the multi-day Hackfort event in Boise in March, 2022 and resulted in community outreach to approximately 40 attendees. The pictures below provide perspective of the structure and outreach conducted at Hackfort.

A task management system and collaborative workspace for knowledge capture and dissemination was also established. Commercial tools like Jira and Confluence were selected as these tools met the requirements while at the same time providing workforce development by training interns in the use of

[1] Raspberry Pi is a trademark of Raspberry Pi Ltd

platforms they would likely see in their careers. The tools are used to help the Cyberdome track work being done while at the same time maintaining a history that can be used to develop future training.

The combination of the AWS cloud-based security control center and the customer-deployed sensor provides the core of our Cyberdome platform. The solution is not only scalable but becomes more cost-efficient at scale as some resources can be shared across clients. The solution is deployable anywhere there is an Internet connection and two available network ports. The solution provides appliances for packet capture and analysis, log management, endpoint detection and response, network and host intrusion detection, vulnerability scanning, threat hunting, and case management.

Throughout this current cohort, the engineers gained valuable knowledge that is directly applicable to working in the cybersecurity field. These skills include secure networking, open-source software configuration, hardware configuration, cloud computing, documentation rigor, and project management. Several of the first cohort engineering students have completed their internships, while the second cohort is just getting started.

Cybersecurity Analyst Contributions

Pre-Cyberdome Activation (July - December 2021)

The first round of analysts was recruited in late 2021, before the initial activation of the Cyberdome. These analysts were instrumental in developing the training and documentation for subsequent cohorts.

Training developed in the online learning management system Canvas was vetted by these analysts and improvements were made. The initial training heavily emphasized basic network and security concepts. Additional training content from TryHackMe was tested and incorporated into the curriculum. Based on feedback from these analysts, additional training was added around the initial security platform Security Onion. This was subsequently replaced with training content from Stellar Cyber.

Documentation of Cyberdome procedures was developed and vetted by the initial group of analysts. The day-to-day operating procedures were initially created around the Security Onion platform and were changed to Stellar Cyber shortly before the activation of the first Cyberdome Client. Documentation is housed in a cloud-based document management system, allowing access for local and remote users.

Analysts were evaluated for their strengths and weaknesses, and a lead student analyst was identified. The lead analyst acts as a primary source of information for the other analysts and provides feedback to the other analysts on incident activity.

Activation of Cyberdome Clients (January - June 2022)

The current service level agreement with Cyberdome clients specifies monitoring coverage from 8 am to 6 pm, 7 days a week.

Upon activation of the first Cyberdome client in mid-January, 2022, analysts moved to a new schedule designed to cover the service level agreement. Shifts were initially set to 4 hours in length and could be performed in the Cyberdome office facilities, or remotely via VPN access. A minimum of two analysts were required to cover each shift. This allowed for redundancy in case an analyst could not cover an assigned shift. As recruiting expanded to other clients, it was determined that 4-hour shifts were not flexible enough for some students who had classes in 4-hour blocks. Schedules starting with the second cohort had shift lengths of 2 hours on weekdays and 5 hours on weekends.

Analyst SOC duties involve triaging alerts and incidents generated by the Stellar Cyber platform. Triaging consists of an initial assessment of the severity of the incident, followed by researching the incident using available resources, and concluding with either resolution or escalation. An escalation chain to the lead student analyst and then the Cyberdome Manager was implemented. Incidents that merited communication with a Cyberdome client were documented and forwarded to the client for further investigation and resolution.

Skill Development

In feedback from various industry partners, it became clear that additional "essential" skill development (aka, "soft skills") would be welcome. A primary skill was identified as being able to present a complicated subject clearly and concisely. To this end, analysts were required to research a cyber security topic or vulnerability and present their findings to other analysts and Cyberdome management.

Continuity of Operations

Several steps were taken to provide continuity of operations across cohorts. These steps involved the cadence of recruitment and personnel additions.

To avoid the disruption that may occur if a cohort ends at the same time a new cohort begins, an overlapping recruitment process was adopted. A typical cohort of students lasts six months. However, a new cohort of approximately seven analysts begins every three months, creating an overlap of cohorts. This ensures that the Cyberdome is staffed with experienced analysts at all times. This also allows for the mentoring of new analysts by more experienced analysts on each shift.

The initial hierarchy of analysts had one student chosen as the lead analyst for that particular cohort. Lead analysts vary in skills from cohort to cohort; to have a strong lead analyst available to all cohorts, a position for a full-time lead analyst was created. Recruitment for this position ended with the successful hiring of an experienced lead analyst in May 2022.

Maturity of Cyberdome Processes

Cyberdome processes are still at an early stage of development. Critical processes, such as those involving incident triage and management are relatively mature and suitable. Ancillary processes, such as analyst feedback and performance monitoring are still in development and will continue through future cohorts. Maturity of processes is an on-going effort and future cohort participants are engaged to build these feedback and performance processes.

Maturity of Analyst Recruitment and Hiring Process

The recruitment and hiring process has greatly improved over the course of three analyst cohorts. Contacts at the various institutions have been made that allow Cyberdome personnel to present directly to students. These presentations have been enormously successful, resulting in more than sufficient analyst candidates.

Objective Two: Reduce critical cybersecurity risks for State, Local, Tribal, and Territorial (SLTT) clients

The IPC, as part of its community outreach efforts, conducts risk assessments for SLTT clientele around the state. Funding for these assessments is outside the scope of the Cyberdome effort. The assessments are mentioned here, however, to show the interwoven service portfolio for rural SLTT clients the IPC provides and represents the ongoing efforts to recruit client communities to the Cyberdome. Funding for future risk assessments was renewed for 2022 and these activities will be used to recruit other communities into the Cyberdome.

The activation of the Cyberdome's first client occurred in mid-January 2022. This provided a real-world experience for our analysts as they monitor the events and alerts. It also initiated building the data store of real-world events that can then be used to further academic research. At the end of the first year reporting period, the IPC and Cyberdome staff are pleased to report that a total of four (4) clients are activated, with another five (5) clients "in-flight" towards activation over the coming months. This puts the Cyberdome at a total number of nine (9) clients, almost double the number in the original grant request. The budget savings to accomplish this came about as a result of platform savings by moving to Stellar Cyber, along with savings from delayed cohort hiring. Further, this doubling of clients and careful first year budget planning does not require any additional funding in future years.

The Cyberdome provides each client access to a Web Dashboard for their particular network through https://cyberdome.us. From there the client can see the number of ongoing alerts, with severity, in real-time. Additionally, clients are informed through email concerning particular incidents which cannot be determined as either benign or false positives. More robust client reporting is still in flight so each client can easily see the number of incidents occurring and being resolved in a format understandable

by a non-technical audience. A list of clients, along with their asset and activation dates are provided in Table 1 below.

Cyberdome Clients			
Name	**Assets**	**Residents**	**Activation Date**
Jefferson County	200	26,000	03/22
City of Sun Valley	200	2,500	01/22
Cambridge School District	100	400	03/22
Midvale School District	200	300	03/22

Table 1. Year-one Cyberdome Client Information

The next reporting period report will outline the efforts to enable clients and present other research objectives.

Objective three: Produce innovative research, tools, and techniques to transfer to commercial efforts

Early-stage development of research, tools, and techniques have come as a result of platform and staffing activation. The Cyberdome team has leveraged available opportunities to conduct research, or develop the following specific items:

Co-PI Dr. Edoardo Serra and his students have been focusing their Cyberdome research effort on the design of Machine Learning systems to detect and explain cyber malicious threats. Part of the research focuses on the use of graph formalism to process security log data (currently, IoT device communications and application API calls) through the use of advanced graph representation techniques. In this context, they have already produced the following publications (all peer-reviewed conference papers that acknowledge the Cyberdome grant):

- Carpenter, J., Layne, J., Serra, E., and Cuzzoccrea, A., 2021. Detecting Botnet Nodes via Structural Node Representation Learning. IEEE BigData 2021: 5357-5364.
- Quebrado, M., Serra, E., and Cuzzoccrea, A., 2021. Android Malware Identification and Polymorphic Evolution Via Graph Representation Learning. IEEE BigData 2021: 5441-5449.

Another part of his research focuses on the explainability of attack classification models to facilitate threat investigation. In particular, the research focus was on automatically associating to subgraphs of

the API call graph to a specific attack technique reported in the Att&ck[2] Knowledge base. Always in the context of explainability, Dr. Serra evaluated standard explanation techniques, called attribution techniques, to explain classification models to detect specific threats in network traffic and power systems. The result of the analysis is that current attribution techniques literature produces inconsistent explanations in the domain of cyber security, and further research effort is required. The following are the related papers already published (all peer-reviewed conference papers or posters that acknowledge the Cyberdome grant):

- Fairbanks, J., Orbe, A., Patterson, C., Serra, E., and Scheepers, M., 2022. Identifying ATT&CK Tactics in Android Malware Control Flow Graph Through Graph Representation Learning and Interpretability. The Thirty-Sixth AAAI Conference on Artificial Intelligence - Student Abstract and Poster Program, 2022.
- Fairbanks, J., Orbe, A., Patterson, C., Serra, E., and Scheepers, M., 2021. Identifying ATT&CK Tactics in Android Malware Control Flow Graph Through Graph Representation Learning and Interpretability. IEEE BigData 2021: 5602-5608.
- Ratul, Q., Serra, E., and Cuzzoccrea, A.., 2021. Evaluating Attribution Methods in Machine Learning Interpretability. IEEE BigData 2021: 5239-5245.

Thanks to such preliminary results, Dr. Serra, in collaboration with PI Vasko, submitted a proposal to the National Centers of Academic Excellence in Cyberdefense (NCAE-C) entitled "Meta Data Traffic Anomaly Detection via Interpretable Temporal Structural Provenance Graph Representation Learning."

The current research of Dr. Serra and his students is on the extended provenance graphs[3] to integrate different security logs and efficient explainable graph representation techniques to better process and interpret the generated provenance graphs. Research papers on such fields are currently in preparation.

Co-PI Dr. Francesca Spezzano and her students have been working on the definition of new organizational security risk measurements with indirect factors through the analysis of information contained in social media and news. In particular, a piece of such research focuses on the idea of monitoring the behavior of the organization's employees over social media. The risk of an organization can be related indirectly to how hazardous the behavior the organization employs over social media. This can be especially true in the case of exposure to social engineering attacks. In particular, Dr. Spezzano focuses on the assumption that the larger the number of employees in an organization that ingenuously spread fake news, the higher the risk that such employees can be deceived by social engineering attacks and expose the organization to risk. In this specific field, Dr. Spezzano published the following peer-reviewed journal paper acknowledging such a grant:

[2] https://attack.mitre.org/
[3] Han, X., Pasquier, T., & Seltzer, M. (2018). Provenance-based intrusion detection: opportunities and challenges. In *10th USENIX Workshop on the Theory and Practice of Provenance (TaPP 2018)*.

- Shrestha A., Spezzano F., Characterizing and Predicting Fake News Spreaders in Social Networks. International Journal of Data Science and Analytics 13(4): 385-398 (2022).

In the same direction of security risk measurements with indirect factors led by Dr. Spezzano, Dr. Serra also contributed by measuring how employees of an organization care about privacy. The assumption, in this case, is that the more the employees disclose private information on social media, the higher the likelihood that such information will be used by malicious individuals to damage the organization. In particular, the research focuses on detecting shared images on social media that disclose private information. Of specific interest in the detection of images that disclose documents. For this specific context, the following peer-reviewed conference acknowledging such a grant was published:

- Serra, E., Squicciarini, A., Ayyapureddi, S., and Ratul, Q., 2021. A Few Shot Transfer Learning Approach Identifying Private Images With Fast User Personalization. IEEE BigData 2021: 1204-1213.

All these factors, even indirectly, can estimate real risk for the organization that cannot be detected otherwise. Thanks to the research and collaboration facilitated by the Cyberdome grant, Dr. Spezzano, in collaboration with Dr. Serra, Dr. Jain, and PI Vasko, submitted an educational proposal to "National Centers of Academic Excellence in Cyberdefense" entitled "Integrated Faculty Workshop on Artificial Intelligence for Cybersecurity.''

Dr. Spezzano currently is working on searching other undirected factors that can estimate cyber risk from social media. In addition, Dr. Spezzano, in collaboration with Dr. Serra, are working together to predict the kinds of targeted organizations and attacks directly from news events. This work is currently done by creating machine learning models that correlate historical news events with known disclosed cyber incidents. With such a model, given the most recent news event, we will estimate the likelihood that a particular kind of organization can be targeted by a specific kind of attack and for which motivation. The prediction of such information is very important in the prioritization of cyber operations. A research paper is in preparation.

Co-PI Dr. Jidong Xiao utilized research time to work with his Ph.D. student Shariful Alam on developing a framework, based on the Intel virtualization technology, for protecting sensitive and private data against cold boot attacks. A full paper is written. It was first submitted to the 2022 International Conference on Dependable Systems and Networks (DSN). The paper was not accepted for publication and the team received critical feedback from the reviewers and is working on revising the paper and are planning to soon submit the revised paper to the 2022 Annual Computer Security Applications Conference (ACSAC).

Co-PI Amit Jain worked with his Ph.D. student on researching machine learning tools to help with election cybersecurity. Part of his time was funded by this grant and a part was funded by another grant. A survey paper is expected to be produced in the next six months.

Assessment and Training Tools

The comprehensive KSA assessment tool as well as competency-based training program can be leveraged by commercial security service providers as a career development tool. PI Vasko is examining likely technology & process transfer opportunities with commercial partners. If a viable route to market is determined, the tools and programs may be transferred to a commercial partner.

As the project is still in an early stage and the platform is nearly activated, other research, tools, and techniques are not expected until later in the project.

Future Plans / Funding Strategy

The Cyberdome team is well on its way to further sustained growth in all objective areas. This section outlines both plans and funding strategies for the Cyberdome efforts.

Future Plans

Some examples of efforts being undertaken in the next reporting period include:

1. Expand the Cyberdome client portfolio to better assist SLTT clients with important cybersecurity functions such as risk assessments, threat intelligence, and community member outreach (e.g. notifications & messaging to residents).

2. Continue to refine processes and operating procedures for current technology platforms while also ensuring our service architecture is open for new technology partners and service enablement for continuing to enhance client deliverables.

3. The penetration testing plan will be used as a basis for building an automated weekly vulnerability scan that will be deployed on Cyberdome assets as well as be made available to Cyberdome clients. A much smaller automated vulnerability scan is planned for use during risk assessments. This will provide further workforce development of cybersecurity systems thinking, vulnerability scanning, and automation, and ensure continuous improvement of the Cyberdome's security posture.

4. Integrate the new technology partners (PlexTrac and HYCU) into the Cyberdome service architecture. This will allow computer science/programming engineering interns to integrate security technologies and present portfolio elements on their resumes after graduating.

5. Continue development of the Virtual City as a training platform. Increase the assets in the virtual city to include more complex storefronts, doctors' offices, workspaces, include simulated transactions, etc. This increases our ability to test from both an offensive and defensive position. It also forms the basis for creating vulnerable systems for use in range exercises with other schools.

6. Pursue commercialization opportunities for the candidate assessment and skill gap training platform.

7. Continually improve training for engineers and analysts based on new methods and approaches. This should include training on how to restore systems when they go down, how to build new system components from scratch, how to monitor the full security grid, and how to scan assets for vulnerabilities.

8. Continue to enhance training for both analysts and engineers. The current plan includes exercises in simulated security events, how to detect and then threat hunt events, and how to manage cases including client etiquette.

Future Funding Efforts

Current plans for future funding models include funding and employer sources. Details of each are provided below.

Federal, State, and private funding sources

The IPC applied for and received an Idaho Workforce Development Council (WDC) Industry Sector Grant equal to $800K over 3 years (approximately $266,000/year). This grant focused on enabling Cyberdome interns through paid efforts similar to those approved by HERC (e.g., 6-month paid internships) and, effectively, doubled the total number of student workers in the Cyberdome. The grant period spans FY'23 through FY'25 with a possible extension into FY'26.

Further funding requests are being put forward in support of Governor Little's Cybersecurity Task Force objectives, of which PI Vasko was a member. This request includes state appropriations equal to four (4) full-time support members, paid internships for up to 55 students across the state, and platform support for up to 18 rural communities.

Employer partners

PI Vasko is actively pursuing sustainable funding from employer partners for this program. An anticipated sustainable funding model will come through the enhanced return on investment employers can achieve by funding an intern stipend for each early-stage cybersecurity career professional. Leveraging the identified "Activation Gap" thesis in our original HERC proposal, employers are spending 6-9 months activating new employees on methods and techniques. Under the thesis that the Cyberdome eliminates up to 3 months of that activation period, then an employer can achieve "twice the training for half the cost." Here is a simple model to validate the opportunity:

- "Fully-loaded" annual salary of Security Analyst: $60,000 base + 35% fringe = $81,000 (Monthly cost: $6,750)
- Three (3) months of salary to provide technical training: $20,250
- Estimated technical training costs: $5,000
- Total hard costs to "activate" a security analyst: $25,250

If an employer provides the Cyberdome half of this expected cost ($12,625) as a gift, the employer potentially receives a tax-deduction AND an employee ready to activate in their environment faster than expected. The reduction in downtime and training costs that are passed on to the Cyberdome enables a doubling of the training time (6 months), enables a better-qualified employee, and helps to reduce the risk to our rural and remote communities around the state.

Patents and Copyrights

There were no patents or copyrights to report at this time.

Startups and Technology Licenses

There were no startups or technology licenses to report at this time.

Expenditure Report

The table below summarizes expenditures associated with the grant project. The project start date was delayed by 2 months in the summer of 2021 as we worked to recruit and onboard a Manager and Lead Engineer to support the project and future interns. This delay in hiring pushed back initial project timelines including the hiring of undergraduate workers and onboarding of new clients. Faculty and staff have worked to quickly catch up and achieve grant goals.

To date, a total of four (4) clients have been onboarded, with several others in the pipeline. In May, a revised annual budget was presented and accepted. This allowed the team to make additional hardware, ticketing, and AWS instance purchases without increasing the total costs associated with the grant. This enabled the team to provide necessary upgrades to our existing clients' hardware, exceed our grant's initial goal of serving five SLTT clients, and increase the quality and volume of data available to our graduate assistant researchers and Co-PI's.

In our first year, the Cyberdome supported 43 total students, faculty, and staff (see **Figure 2**). Our first cohort of 8 students finished their internship experience in the Cyberdome. The second cohort is mid-way through and meeting expectations. There are currently 16 students who will complete their work experience by the end of the summer and an additional 9 are scheduled to graduate from the Cyberdome program in mid-November. Three Graduate Assistants were hired in August 2021 to assist with the development of the Cyberdome platform and conduct research while our five co-PI's continue to serve as advisors to GAs and execute their research.

Additionally, we have purchased a subscription to a cybersecurity training platform, which will help us to further upgrade our interns' offensive and defensive security skill set.

Projected Expenditures for July 1, 2021 to June 30, 2022[4]				
Category	**Annual Budget**	**Revised Budget**	**Projected Spend**	**Remaining Amount**
Wages	$474,161	$437,522	$437,522	$0
Fringe + GA Scholarship	$135,339	$124,182	$124,182	$0
Equipment and Other Expenses	$90,500	$138,300	$138,388	$(88)[5]
Total	**$700,000**	**$700,00**	**$700,088**	**$(88)**

[4] Please note: The financial reporting period for actual spend is through the middle of the May period because the June financial month has not closed, and will not be closed by the required reporting date of June 30. This annual report reflects a best projection because of this limitation. A recommendation to HERC is to require the mid-year and annual reports on the 1st of the 8th month (February) and 14th month (August), respectively, so accurate period actuals can be presented.

[5] University funds will be used to cover this deficit.

BOISE STATE UNIVERSITY

ID-SBOE HERC IGEM22-002

Boise State University Food & Dairy Innovation Center

Year 1 Annual Report: July 1, 2021 – June 30, 2022

Contributors:

Owen McDougal, PI: BSU Professor and Chair of Chemistry and Biochemistry

Julie Oxford, Co-PI: BSU Distinguished Professor of Biological Sciences

Lisa Warner, Co-PI: BSU Assistant Professor of Chemistry and Biochemistry

JoAnn Lighty, Co-PI: BSU Dean of College of Engineering, Mechanical & Biomed. Engineering

Jim Browning, Co-PI: BSU Assoc. Dean of Engineering, Electrical & Computer Engineering

Prepared for IGEM HERC by Owen McDougal

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IGEM HERC FDIC

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IGEM HERC FDIC

1.0 Project Overview

A. Project Information

Funding Agency:

- Idaho Global Entrepreneurial Mission Higher Education Research Council

Awarded Institution: Boise State University

Grant Number: IGEM 22-002

Project Title: Boise State University Food and Dairy Innovation Center

Principal Investigator: Owen McDougal, Ph.D., Professor and Chair

Co-Principal Investigators:

- Assistant Professor Lisa Warner,
- Distinguished Professor Julie Oxford,
- Professor and Assoc. Dean, College of Engineering, Jim Browning,
- Professor and Dean of the College of Engineering, JoAnn Lighty

Report Type: 1st year annual progress report: July 1, 2021 – June 30, 2022

B. Executive Summary

The $684,000 IGEM HERC grant funds available in FY22 have been spent on personnel ($136,100), infrastructure ($250,000), capital equipment ($259,200), and operating expenses/travel/recharge center fees ($38,800). The objectives of the Food and Dairy Innovation Center (FDIC) are to create critical infrastructure and generate sponsorship for sustainable industry prioritized research. In FY23, we will begin construction of FDIC laboratories, purchase additional equipment to bolster research capabilities, secure extramural funding with academic and industry partners to expand operations, and recruit and retain student and full-time employees to staff the FDIC.

2.0 Introduction

IGEM HERC funds have been used to initiate the establishment of a Food and Dairy Innovation Center (FDIC) at Boise State University. The FDIC will serve as a research core facility for regional academic institutions and industry. We seek to catalyze the modernization of Idaho's food and dairy processing industries by creating innovative technologies, providing food safety and food security training, and educating the next generation of workers to be prepared to lead in a high-tech, artificial intelligence (AI) dominated work environment. The FDIC will be a public-private lightning rod to spark economic development for all of Idaho. The FDIC is complemented by innovative transdisciplinary programs at Boise State University, and will aim to strengthen collaboration with the University of Idaho and Idaho State University, with the goal of becoming a nationally-recognized resource for research and development, for student scholarship and internship programs (e.g. VIP), and for driving economic expansion for Idaho industry. The objectives of the FDIC are to advance and create new processing technologies, establish a robust employee pipeline from university to private sector, and generate know-how and implementation of modern technology aimed at reducing usage of critical natural resources.

Year 1 – review of FY22 task list:

1) Construct Module 1
2) Hire technicians or postdocs
3) Recruit students (Ph.D., M.S., Undergraduate)
4) Purchase instrumentation
5) Fundraise for Module II

IGEM HERC FDIC

3.0 Year 1 - Summary

Table 1 provides a correlation between proposed metrics and achievement from the first year of IGEM HERC funding from 7-1-2021 thru 6-30-2022.

Table 1. FY22 metric accomplishments

Year 1 Metric Proposed	Metric Accomplishment	Comment
Construct FDIC Module I	Modules I-III designed, budget estimate, out to bid	Funds are available to construct Modules I & II
External Funding $500k	$668,541	5 new grants since 7-1-21
FDIC Students Trained 3-5	31	Includes research and VIP
Patents-Publications 2-4	6 publications	2 food, 1 dairy, 3 natural product, pharmacology & toxicology
Grants & Funding - 6 submissions	8 submissions	5 awards, 2 declined, 1 pending
Internships & Jobs 2-4	6 interns, 2 jobs	Positions in ID, CA, MN

A. Project accomplishments for the reporting period

1) **Construct Module 1:** IGEM HERC funds ($250,000) have been spent on laboratory space architectural design and planning for the third floor of the Micron Center for Materials Research (MCMR) (see **Figure 1**). IGEM HERC funds will be complemented by state of Idaho infrastructure funds dispersed to BSU that will be used to build labs on the third floor of the new building. Utilizing the IGEM HERC funds (3 yr. total = $650,000) and state funds, two 650 sq. ft. modules will be built and the space dedicated to the FDIC. The laboratory completion date is estimated to be Fall of 2023. The IGEM HERC funds have been used to pay the State Division of Public Works (DPW) for interagency billings they send to Boise State Architectural and Engineering (A&E) Services for this project. Since the state holds the contracts, they have paid the vendors directly and then billed Boise State for what they have been authorized to spend for this construction project. At this point in time, lab design plans have been made, a budget for the project estimated, and contractors have been bid to do the construction.

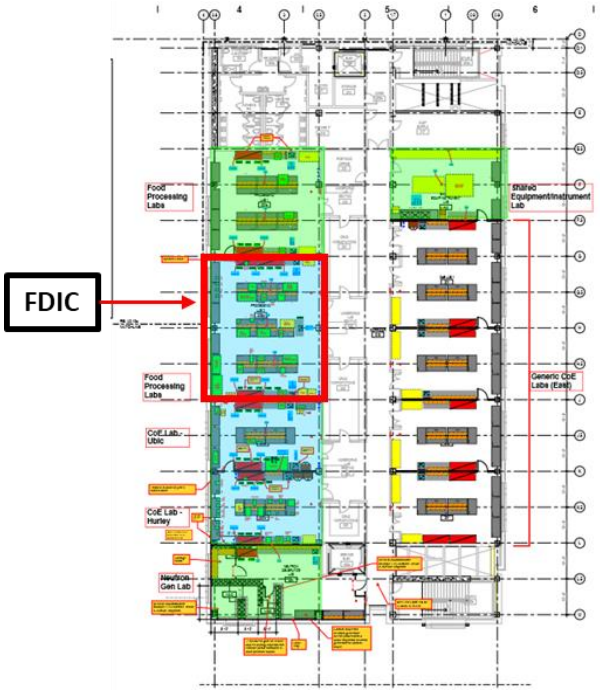

Figure 1. MCMR level 3 floor plan with FDIC Module I&II labs boxed in red outline.

2) **Hire technicians or postdocs:** Several employees have been hired to work on FDIC associated projects. Co-PI Browning has used HERC funds to support engineering activity conducted by postdoctoral researcher, Dr. Marcus Pearlman, in food safety and machine learning. Toward the end of FY22, Dr. Browning added postdoctoral researcher, Dr. Ranajoy Bhattacharya, to the project. Co-PI Warner used HERC funds to support the effort of research technician Jayden Brandt, and PI McDougal used funds to support the effort of research technician Rose Saxton. PI McDougal conducted three searches for a full-time postdoctoral researcher before he gained acceptance of offer by Dr. Obyedul Azad, who will begin July 2022. Funds were also used to support the effort of Diane Smith, a grant administrator who recorded the minutes of meetings and gathered reporting data for the semi-annual IGEM HERC report. Tracy Yarnell was similarly compensated for one month of salary to establish the FDIC web site and manage news and correspondence surrounding center activity (**Figure 2**).

IGEM HERC FDIC

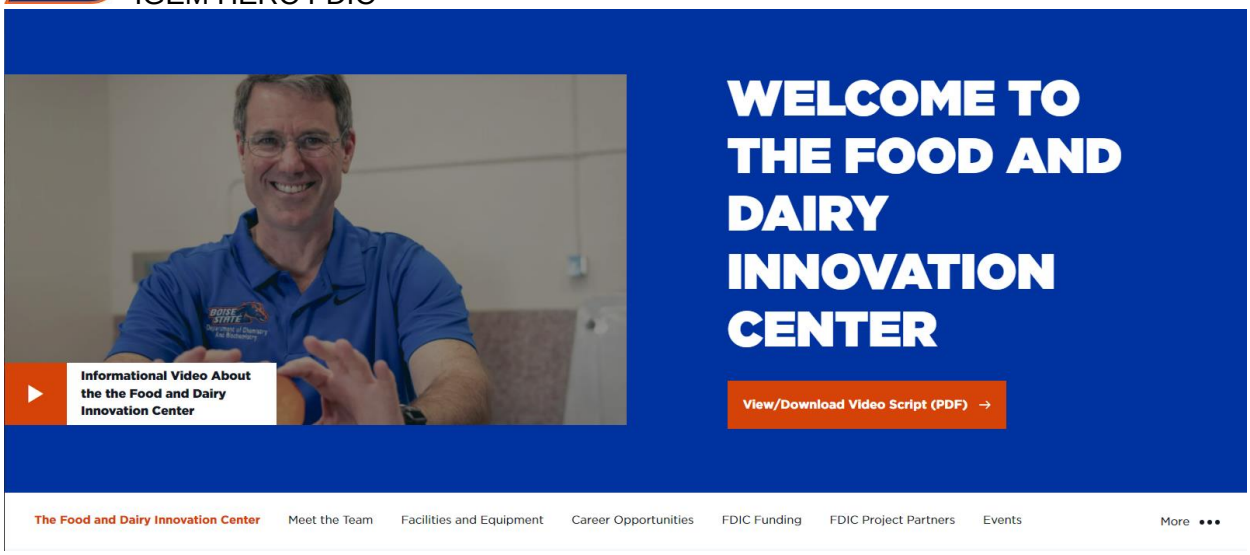

Figure 2. Homepage for the FDIC website (https://www.boisestate.edu/fdicenter/).

3) **Recruit students (Ph.D., M.S., Undergraduate):** The FDIC has generated considerable interest from students at Boise State University and from around the region. Two Biomolecular Science (BMOL) Ph.D. students, one Chemistry MS student, and a Computer Science Ph.D. student joined the McDougal lab in Spring 2022. BMOL Ph.D. student Madison Dirks applied for and received three years of funding from BUILD Dairy ($138,000) to support her work on the use of the dairy protein glycomacropeptide as a food ingredient, bioactive supplement, and glycosylated protein for method development. Her work was co-sponsored by Agropur. Madison is utilizing instrumentation, equipment and supplies provided by IGEM HERC. BMOL Ph.D. student Elizabeth Ryan has drafted a white paper for submission to the National Dairy Council that may fund her work focused on the use of pulsed electric field (PEF) to improve the efficiency of dairy protein powder spray drying and subsequent solubility of the resultant powder. Her work is in collaboration with food scientists at the University of Minnesota and engineers at Food Physics Group. In a separate National Dairy Council funded project to utilize infrared spectroscopy for qualitative and quantitative analysis of dairy proteins in milk, it became apparent that machine learning and artificial intelligence solutions would be required. Collaboration between Dr. McDougal and Dr. Tim Andersen in the Computer Science (CS) department at Boise State led to the recruitment of CS Ph.D. candidate Habeeb Babatunde to code software to simultaneously identify and quantify multiple proteins in milk by infrared spectroscopy. Mr. Babatunde reported on his project at the annual BUILD Dairy conference in Provo, UT in June 2022. Dr. Brandon Nelson of Daisy Brand immediately engaged with Dr. McDougal regarding Mr. Babatunde's work and a draft proposal is progressing that will fund Mr. Babatunde's graduate education as well as that of Ms. Rianat Olabisi, a

Chemistry M.S. student. More recently, Micron School of Materials Science and Engineering second year Ph.D. student Mark Skinner joined Dr. McDougal's lab to work on heat and mass transfer kinetic modeling in PEF treated potato, grape, and barley projects. Mr. Skinner earned his ACS certified chemistry B.S. degree from Boise State, and he conducted his undergraduate capstone research in Dr. McDougal's lab, studying acrylamide formation in fried potato products.

The undergraduate student recruitment into food and dairy projects is a very exciting initiative made possible due to FDIC funding. Co-PI Warner and research technician, Jayden Brandt, have designed a Vertically Integrated Project (VIP) course to be offered in fall of 2022. The VIP course is called *Food Systems*, and the audience will consist of chemistry, biology, engineering, and computer science students seeking to explore independent work into all aspects of food systems. The new postdoc, Dr. Obyedul Azad will take an active role in VIP course management, alongside McDougal and Warner. It is the goal of this year-round initiative to establish a student training pipeline leading to good career jobs in Idaho. This program will be available to students at the 200, 400 and 500 levels, to study *Food Systems*; we estimate the experience will serve a student population of around a dozen students per semester. The academic year will provide context and training to the students for food and dairy projects, and the summer will provide in-depth summer research experiences both at Boise State and through student exchange opportunities at sister institutions in Idaho and internships with industry partners. The *Food Systems* program will draw on expertise from academic and industry professionals to provide students with relevant, real world examples of emerging threats to food supply chain resilience, and provide a networking platform from which internship partnerships can be explored. In addition, Co-PI Browning, in collaboration with Biochemistry Professor Ken Cornell, have been supporting a VIP: *Plasma Medicine and Agriculture* for 7 years. This program includes biology, chemistry, and engineering students studying the use of Cold Atmospheric pressure Plasma (CAP) to kill/remove bacteria and viruses from surfaces in food processing including for dairy plants. Over this last year, 16 students participated in the course and, in addition to generating meaningful research results, they and their students presented dozens of conference posters and presentations. **Table 2** shows a summary of student participants impacted by the FDIC project team in FY22.

Table 2. FDIC influenced participants - FY22.

FDIC Student Participation FY22	
Type of student	# of Students
Undergraduate Students	9
Graduate Students	6
Student Industry Internships	6
Undergraduate VIP Students	16

4) **Purchase instrumentation and equipment:** In FY22, capital equipment expenditures included an Agilent 1260 Infinity II liquid chromatography system equipped with a diode array detector, refractive index detector, and single quadrupole mass spectrometer (Product: SYS-LM-QUAD-E) for $205,040, a nitrogen generator ($24,858), an Eppendorf 5920 R Benchtop Centrifuge ($19,104), an OHAUS MB120 moisture analyzer ($4,812), and an Äkta Protein Chromatography System ($10,174). **Figure 3** shows instrumentation and equipment purchased using IGEM HERC funds.

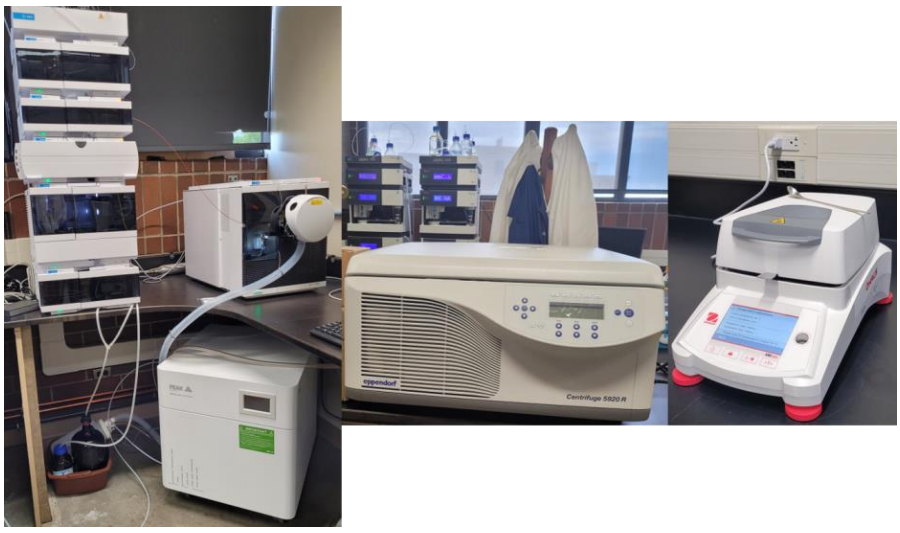

Figure 3. LC-DAD-RI-MS/nitrogen generator, centrifuge, and moisture analyzer (left to right).

IGEM HERC FDIC

- Agilent 1260 Infinity II liquid chromatography system (LC-DAD-RI-MS)
  - Potato and wine sugar analysis
  - Wine organic acid analysis
  - Plant extract analysis – steroidal alkaloids and cardiac glycosides
- Nitrogen generator
  - Provides nitrogen to the LCMS system
- Eppendorf 5920 R Benchtop Centrifuge
  - Used in potato, wine and plant analysis
- OHAUS MB120 moisture analyzer
  - Malted barley moisture analysis
  - Dairy protein moisture analysis

5) **Fundraise for Module II:** PI McDougal has been working with Melanie Bannister, Senior Director of Development, College of Arts and Sciences, Boise State University to secure a $1.1M donation for FDIC infrastructure and instrumentation. In addition, ongoing discussions have been happening between PI McDougal and Dr. Eric Bastian of Dairy West to secure a gift of a dairy protein spray dryer, and John Barber of Clextral North America for the acquisition of a twin-screw extruder.

B. Plans for FY23

Table 3 shows the FY23 metrics proposed in the 2021 IGEM HERC submission.

Table 3. Proposed metrics for FY23

Year 2 Metric Proposed	Metric Progress	Comment
Construct FDIC Module II	On track	Construction of modules will begin FY23 for completion fall 2023
External Funding $1M	Grants and gifts	Progress is being made
FDIC Students Trained 5-10	Gaining momentum	Est. 25 students fall 2022
Patents-Publications 3-5	2 papers in review	On track
Grants & Funding - 10 submissions	10 submissions planned	Expect the grant submission number to increase
Internships & Jobs 5-10	On track	Industry alignment and engagement is on the rise

IGEM HERC FDIC

1) **Collaboration:** PI McDougal plans to: (1) work with Agropur on a BUILD Dairy sponsored project focused on glycomacropeptide; (2) work with Daisy Brand to draft a BUILD Dairy grant targeting the use of artificial intelligence to interpret infrared spectra of milk for qualitative and quantitative determination of dairy proteins; (3) initiate a new project with Glanbia to study vitamin degradation kinetics in food products; (4) submit a National Dairy Council proposal to explore the use of PEF in dairy protein powder production; (5) continue discussions with Clextral to obtain a twin-screw extruder at Boise State University; (6) submit an NSF Convergence Accelerator grant with collaborators at BSU, UI, USU, and UMN aimed at dairy protein powders; and (7) make progress on current projects focused on wine, barley, potatoes, and dairy products.

2) **Personnel and equipment investment:** In FY23, Dr. OB Azad will begin as a new postdoctoral researcher with effort dedicated to enhancing academic and industry partner access to the FDIC. Dr. Azad will provide training and mentorship of students, and lead Food Systems VIP course activities. BMOL Ph.D. student, Elizabeth Ryan will be funded on this IGEM HERC grant until her National Dairy Council grant is awarded. The grant application process opens July 2022. Equipment purchases for FY23 will include a Dumas method nitrogen analyzer, UV-Vis spectrophotometer, water bath, titrator, refractometer, and heating blocks for Soxhlet extraction: est. **$95,000**.

    - Velp nitrogen analyzer- $39,987
        - Nitrogen/protein analysis of food products including barley and dairy
    - Agilent Cary 60 UV-Vis spectrophotometer- $34,729
        - Analysis of wine, barley and dairy products
    - Thermo Scientific™ Precision™ Shaking Water Bath- $3,740
        - Barley analysis, potato blanching, microbiology, etc.
    - Multiparameter Benchtop Titrator- $14,895
        - Barley and wine sulfur dioxide, titratable acidity, volatile acidity, reducing sugar content and Free Amino Nitrogen (FAN) analysis
    - Laxco™ Handheld Digital Brix/RI Refractometer- $2,424
        - Sugar analysis for barley and wine
    - Heidolph™ Heat-On Blocks (250mL)- $2,914
        - Soxhlet extraction temperature control

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3) **Extramural funding planned submissions for FY23**

A. NSF Engines Concept Paper and potential Type I proposal

Investigators: Browning, Cornell, Bhattacharya

Agency: USDA Food Safety

B. Title: RF Wave Detection of Food Pathogens in Food Processing Facilities Using Machine Learning

Investigators: Browning, Cornell, Bhattacharya

Agency: USDA Food Safety; Amount: $600k

C. Title: Cold Plasma Treatment of Agricultural Seeds to Remove Contamination

Investigators: Cornell, Browning, Plumlee

Agency: USDA Food Improvement; Amount: $600k

D. Title: Building Sustainable Systems in Food Manufacturing

Investigators: Browning, Cornell, Serra, Plumlee, Loo, Bhattacharya

Agency: NSF; Amount: $500k

E. Title: Sustainable Food Processing

Investigators: Browning, Cornell, Serra, Plumlee, Deng, Saticie, Lu (Idaho), Dillman (Lubrication Sciences International)

Agency: USDA SAS Program; Amount: $10M

F. Title: NSF Convergence Accelerator Track J: Dairy Protein Product Research and Innovation Hub

Investigators: McDougal, Andersen (BSU), Unlu (UI), Sharma (USU), Mallikarjunan (UMN), Hamlett (UI)

Agency: NSF; Amount: $750k

G. Title: Assessing the Influence of Protein Glycosylation on Product Development

Investigators: McDougal, Dirks (BSU), Rao (Agropur)

Agency: BUILD Dairy; Amount $138k

H. Title: Vitamin Degradation Kinetics Across Dairy Products

Investigators: McDougal, van Oudtshoorn (BSU), Ward (Glanbia)

Agency: BUILD Dairy; Amount $138k

I. Title: Chemometric Analysis of Dairy Proteins from Infrared Spectra

Investigators: McDougal, Andersen (BSU), Babatunde (BSU), Olabisi (BSU), Nelson (Daisy Brand)

Agency: BUILD Dairy; Amount $200k

J. Title: Improvement to Dairy Protein Properties Using Pulsed Electric Field Application

Investigators: McDougal, Gratzek (Food Physics/UGA), and Mallikarjunan (UMN)

Agency: National Dairy Council; Amount $225k

4.0 Summary of Budget Expenditures

Table 4 shows the IGEM HERC budget expenditures from July 1, 2021 – June 29, 2022.

Table 4. Budget summary of funds spent from IGEM HERC to support the FDIC in FY22.

	Year 1 Budget Summary Updated 6/29/2022					
	Year 1 Budget	Revised Budget	Total Expenses	Balance	Available Balance	Burn Rate
Salary	119,006.00	99,253.16	(99,253.16)	0.00	0.00	100%
Fringe	44,833.00	36,799.08	(36,799.08)	0.00	0.00	100%
OE	45,101.00	38,096.16	(38,096.09)	0.07	0.07	100%
Travel	9,900.00	675.52	$ (675.52)	0.00	0.00	100%
Capital	455,040.00	509,176.08	(509,176.08)	0.00	0.00	100%
Student	10,120.00	0.00		0.00	0.00	100%
Sub Total	684,000.00	684,000.00	(683,999.93)	0.07	0.07	100%
Total Costs	684,000.00	684,000.00	(683,999.93)	0.07	0.07	100%

5.0 Collaborations

Summary Statement: PI McDougal has initiated research projects involving University of Idaho faculty and staff at the Caldwell Food Technology Center, Parma Research and Extension Center, and is working on proposals with faculty at the main campus in Moscow and extension site in Twin Falls. Industry centered projects span collaboration across the wine industry (Cinder, Telaya, Split Rail wineries), Anheuser Busch, Food Physics Group, potato chip processors (Roots, Teton Valley, etc.), Agropur, and Daisy Brand.

A. Leverage existing infrastructure and expertise

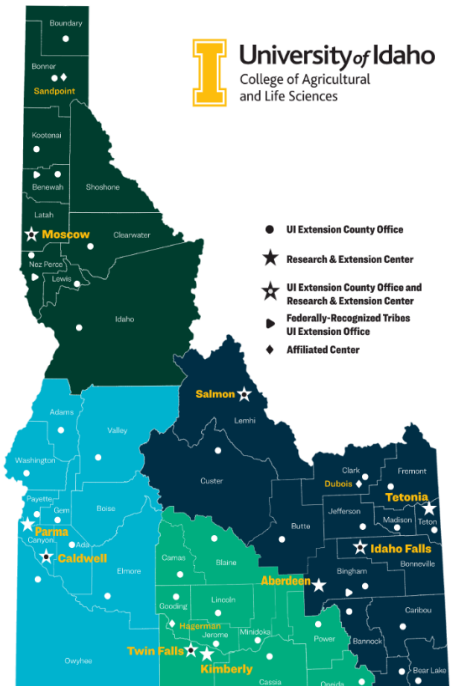

Figure 4. UI extension sites in Idaho.

FY22 outreach has focused on University of Idaho extension offices, which represent the vast majority of infrastructure (see **Figure 4**) and expertise associated with agriculture in ID. Food and dairy projects that utilize the resources made available by the FDIC in FY22 have involved the following existing facilities and professionals.

- UI Parma Research and Extension Center with Professor Mike Thornton
- UI Food Tech. Center with Director Josh Bevan
- UI Moscow with Emeritus Prof. Joe Guenther
- UI Moscow with Assoc. Prof. Gulhan Unlu
- UI Moscow with Dist. Prof. Carolyn Bohach
- UI Moscow with Prof. Sam Minnich

Efforts in FY23 will be made to expand the sphere of influence of the FDIC to Idaho State University facilities, faculty and students. Prior work by PI McDougal and Idaho State University Professor Jim Groome has been supported through the Idaho INBRE program, and utilization of the Molecular Research Core Facility was sponsored by BUILD Dairy and Gossner Foods Co. As the FDIC gains resources and personnel, the opportunities for engagement will continue to expand. McDougal plans to meet with ISU faculty to discuss opportunities made available through the FDIC in FY23. Dr. Lighty discussed with Dean Mike Parrella, as did the INL CAES Director, the NSF Engine Type 1 proposal and, specifically, the importance of the CAFE project to the effort for the state of Idaho. The lead will likely be a non-profit (concept paper is due June 30, 2022 and Dr. Lighty will submit), and Type I is due in September. The NSF Engine Type-1 grant title is *Land, Water, and Energy Innovations for a Future Snake River Basin Regional Innovation Engine*.

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B. Lab availability

The FDIC is still in the early stages of development and access to instruments and personnel located in the 1,000 sq. ft. of lab space that PI McDougal manages are accessible to external users. In FY23, McDougal's lab will conduct dairy protein and plant secondary metabolite quantitative and qualitative analysis, optical spectroscopy, and analyte characterization, Warner's lab will focus on protein biochemistry, Oxford's Biomolecular Research Center will provide an environment for cell culture work, advanced mass spectrometry analysis, and confocal microscopy to image cells, Browning's lab will conduct studies involving engineering, food safety and machine learning, and Lighty will consult regarding heat and mass transfer, and kinetics of food processing. Once the FDIC labs are completed in fall 2023, essential instrumentation will be consolidated into the Center to facilitate external user access through a recharge center infrastructure.

The sustainability plan for FDIC instrumentation and personnel includes the establishment of a recharge center through Boise State University. The FDIC recharge center will operate in concert with other core facilities at Boise State University to provide easy access to internal and external customers at a reasonable cost. Internal customers include members of Boise State University and faculty co-investigators from other institutions, while external customers are those at academic or industry settings outside of Boise State University. The vision for lab availability is to rely on research faculty, postdocs/research technicians and graduate students to facilitate sample preparation and data acquisition for customers. The FDIC recharge center will be modeled after the successful Biomolecular Research Center (BRC) for which project team member, Distinguished Professor Julie Oxford, serves as the BRC Director. Co-PI Oxford has generously provided guidance to PI McDougal to ensure the foundation is well established to secure FDIC sustainability and availability to all.

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6.0 Demonstration of Economic Development/Impact

A. Patents, copyrights, plant variety certificates

Not available

B. Technology licenses signed, start-up businesses created, and industry involvement

- *Food Physics Group (FPG)* in Boise, ID, has been involved in personnel training associated with pulsed electric field (PEF) system treatment of potatoes, collaboration for the pursuit of external funding through IGEM Commerce, and access to their applications laboratory. FPG is a collaborator on three funded projects with PI McDougal.
- *Anheuser Busch* in Idaho Falls, ID, has partnered for a successful IGEM Commerce grant and subsequent supplemental grant associated with PEF treatment of barley to accelerate germination, and reduce water and energy demand.
- *Glanbia Nutritionals* in Twin Falls, ID, has provided facility tours and research priority projects that they will sponsor. It is expected that Glanbia will sponsor a project for 1-2 students in FY23.
- *Agropur USA* in Jerome, ID, has discussed research priority projects that they will sponsor, student internship opportunities, and hiring of former students (Tyson Hardy). Agropur has sponsored a project for BMOL Ph.D. student Madison Dirks, and provided a summer internship for BMOL Ph.D. student Joseph Collins.
- *High Desert Milk and Hyacinth Proteins* in Burley, ID have sponsored therapeutic drug development from agricultural sources, which has supported student research experiences (Joseph Collins).
- *Lactalis American Group* of Nampa, ID, has provided student internship opportunities associated with cheese quality assurance evaluation (Siomara Escobar).
- *Cinder Wines* of Garden City, ID, has partnered for a collaborative research project to explore the use of PEF to make better wine.
- *Telaya Wine Co.* of Garden City, ID, has partnered for a collaborative research project to explore the use of PEF to make better wine.
- *Split Rail Winery* of Garden City, ID, has partnered for a collaborative research project to explore the use of PEF to make better wine.
- *DuBois Chemical* of Nampa, ID, has provided student internship opportunities associated with specialty chemical formulation quality control (Delaney Odell and Robel Clifton).

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- *1,4-Group Inc.* of Meridian, ID, has provided student internship opportunities associated with potato sprout inhibitor quality control (Alex Whittington).
- *J. R. Simplot Co.* of Boise, ID, has provided employment for a former student (Kyle Meyer).
- *Daisy Brand* of Dallas, TX, seeks to sponsor student research to use AI in dairy protein chemometric analysis using infrared spectroscopy in FY23.
- *Lubrication Sciences International* of Boise, ID makes coatings that are being studied as a method to inhibit pathogen adhesion in food processing.

C. Private sector engagement

The private sector was very engaged with the FDIC in FY22 and FY23 looks to be even better. At the June 2022 BUILD Dairy annual meeting in Provo, UT, PI McDougal was able to connect with representatives from Agropur, Glanbia, and Daisy Brand that each expressed interest to sponsor new projects through BUILD Dairy, the National Dairy Council, or internal funding mechanisms. These same companies and several others (Food Physics Group, Clextral North America, and maybe even Chobani) have expressed interest to serve as collaborators for a National Science Foundation Convergence Accelerator grant together with academic partners from BSU, UI, USU, and UMN.

D. Jobs created

In FY22, two students obtained full time employment at J.R. Simplot Co. (Kyle Meyer) and Agropur USA (Tyson Hardy). Another five students have earned internship opportunities through Lactalis American Group (Siomara Escobar), DuBois Chemical (Delaney Odell and Robel Clifton), 1,4-Group (Alex Whittington), Agropur (Joseph Collins), and Glanbia (Rebecca Miller).

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E. External funding – Food and Dairy

Table 5 shows the grant activity for McDougal, Browning and Warner associated with food and dairy research projects.

Table 5. External funding activity associated with the FDIC.

NAME (List/PI #1 first)	SUPPORTING AGENCY AND AGENCY ACTIVE AWARD/PENDING PROPOSAL NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
McDougal - PI	Idaho Department of Commerce: Active: Sponsor Award Number: 004504	$48,000	1/15/2022 – 8/30/2023	0 FTE	Economic benefit of PEF treated barley for breweries
McDougal - PI	Dairy Management, Inc. Active: Sponsor Award Number: 9133	$151,685	6/5/2020 - 8/6/2023	8% (0.08FTE)	Cost Effective Dairy Protein Certification Method
McDougal – PI	Idaho Department of Commerce: Active: Sponsor Award Number: 004504	$291,770	3/31/2021 – 6/15/2023	8% (0.08FTE)	PEF Potato Processing Advantage
McDougal - PI	Idaho State Board of Education: Active: IGEM22-002	$2,098,774	7/1/2021 – 7/1/2024	15% (0.15FTE)	Boise State University Food and Dairy Innovation Center
McDougal – PI	Western Dairy Center, BUILD Dairy: Active	$137,400	2/1/2021 – 5/15/2023	0 FTE	Spectroscopic Investigation of Bioactive Protein Constituents in Whey
McDougal – PI	Idaho State Department of Agriculture: Awarded	$125,000	1/15/2022 – 9/30/2023	8% (0.08FTE)	Impact of smoke on potato growth, storage and profitability
McDougal – PI	Idaho State Department of Agriculture: Awarded	$164,784	1/15/2022 – 8/15/2023	8% (0.08FTE)	Improving Grape Extraction with PEF to Make Wine Better
McDougal - PI	Idaho State Department of Commerce: Awarded	$192,757	1/15/2022 – 12/31/2022	8% (0.08FTE)	Economic benefit of PEF treated barley for breweries
McDougal - PI	Western Dairy Center, BUILD Dairy: Awarded	$138,000	7/1/2022 – 6/30/2024	0 FTE	Assessing the Influence of Protein Glycosylation on Product Development
McDougal – Co-PI	National Institute of Food and Agriculture/USDA: Declined	$57,489	5/15/2022 – 1/15/2023	4% (0.04FTE)	mRNA vaccine technology adapted for delivery of novel gene/protein to strawberries
Browning – PI	NSF Future Manufacturing: Declined	$500,000	1/15/23- 1/14/25	4% (0.04 FTE)	Building Sustainable Systems in Food Manufacturing
Warner - PI	NSF Major Research Instrumentation (MRI): Pending	$886,232	8/1/22 – 2/28/24	0 FTE	Acquisition of a 600 MHz NMR Console and Cryoprobe to Support Research and Education at Boise State University: Pending

F. Other pertinent information

Boise State University has just hired biophysical chemist, Dr. Konrad Meister, who studies ice nucleation and proteins that inhibit ice formation. Meister has worked on such things as the fundamental understanding of freezer burn in ice cream. Dr. Meister has accepted

the tenure-track assistant professor position at Boise State University and BUILD Dairy has contributed to his startup package.

Co-PI Lighty has been asked to join a task force working group initiated by American Society of Agricultural and Biological Engineers (ASABE) President Paul Heinemann and led by Jim Jones. The task force is to recommend mechanisms to create alliances that connect and bring together ASABE with other professional societies and public-private sectors with expertise and tools to address complex and diverse issues associated with the Transforming Food and Agriculture in Circular Systems (TFACS) initiative. This is a result of one of the recommendations from an earlier envisioning session, which Lighty participated in, where alliances that connect and bring together ASABE with leaders of other professional societies and public-private sectors was addressed as an important step to contribute disciplinary expertise to address complex issues associated with TFACS.

Browning has achieved research results in two areas: 1. Cold Atmospheric pressure Plasma (CAP) and 2. Radio-frequency (RF) wave detection of bacterial biofilms.

1. Our CAP system, shown in **Figure 5**, utilizes argon or air to create ionized gas (plasma) to kill or remove bacterial biofilms from surfaces. In the figure, the first image shows a planar array for treatment of surfaces and the second image shows a radial array for treating surfaces inside pipes such as in a dairy processing facility. **Figure 6** shows example results of a single etch element removing bacterial biofilms (*pseudomonas fluorescens*) from a stainless steel surface. The hazy material on the metal coupon is biofilm and a clearly visible channel has been etched into the biofilm as seen in the images for 1 min and 5 min of CAP operation. Other results have demonstrated killing of such bacteria on a variety of surfaces including glass, steel, and plastic.

2. We have been developing a new method to detect bacterial biofilms in metal pipes and pasteurizers as are found in dairy processing plants. This method involves launching RF waves into pipes and structures in the 1-5 GHz frequency range to measure the attenuation and impedance of the RF wave in the pipe or the resonant frequency of the cavity formed by the pasteurizer. These techniques should allow us to detect the formation and buildup of bacteria. Our team has simulated such a concept using the CST Studio software where we have clearly demonstrated via simulation that the impedance and resonant frequency will in fact change with bacterial build-up.

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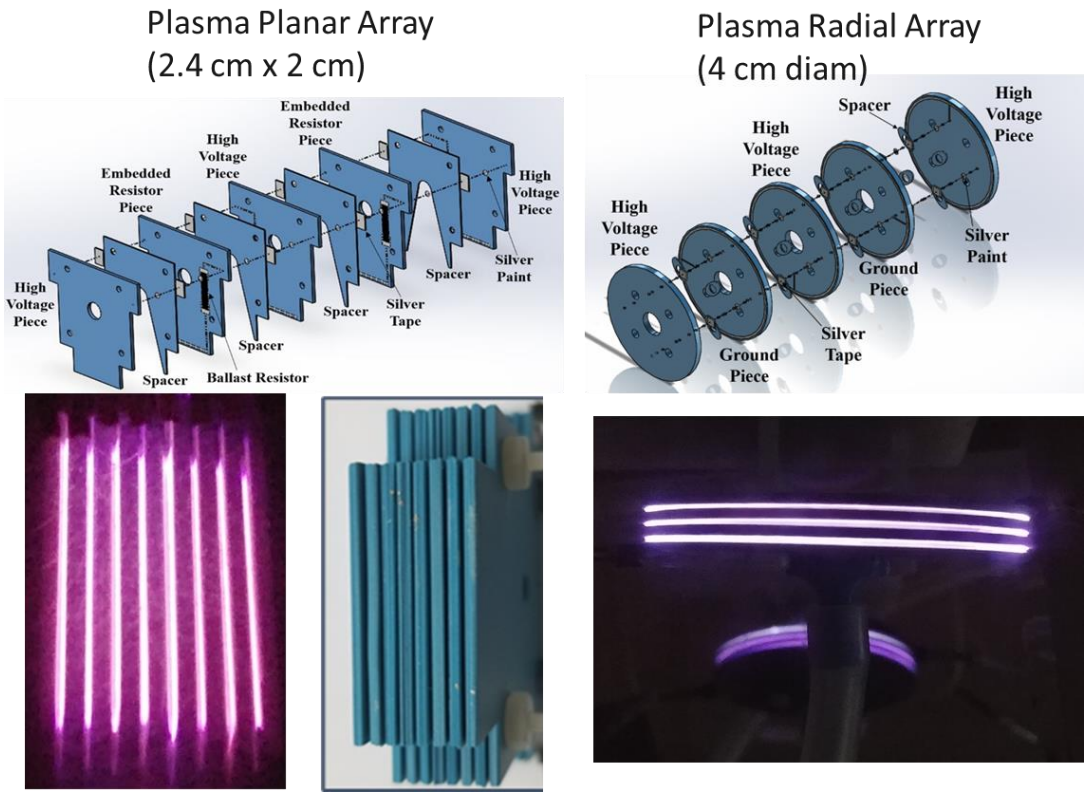

Figure 5. Pictorial drawings and images of our (left) planar CAP array and (right) radial CAP array for killing and removing pathogens from surfaces in food processing.

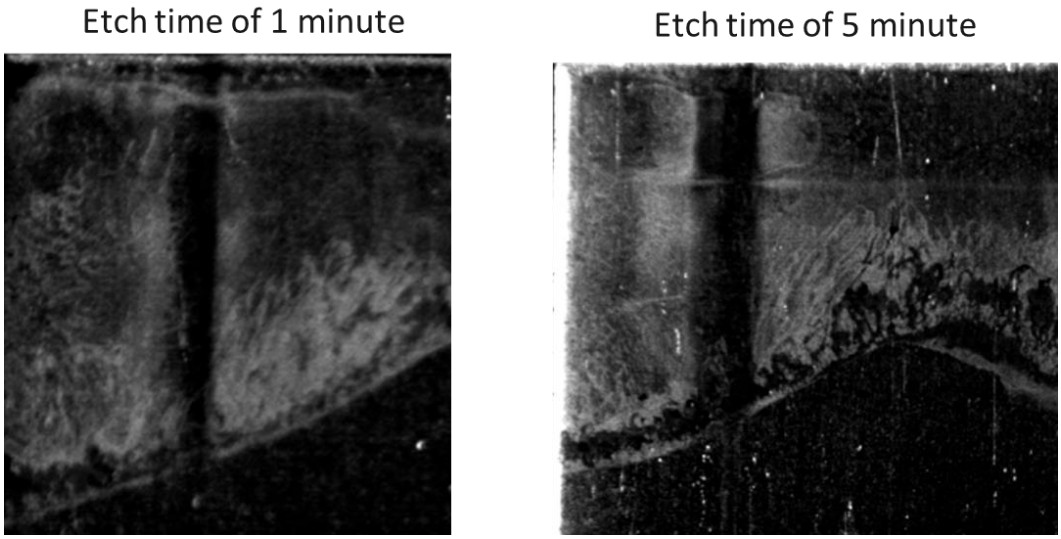

Figure 6. Images showing etched channels in a biofilm on stainless steel for (left) 1 min and (right) 5 min of CAP exposure.

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7.0 Faculty and Student Participants as a Result of Funding

Table 6 shows the faculty, staff and students that are involved in research that benefits from the facilities available in the FDIC.

Table 6. FDIC participant listing.

Person	Title/Position	Project/Topic
Owen McDougal	PI - Prof. Chemistry	FDIC / food and dairy research
Lisa Warner	Co-PI – Assist. Prof. Chemistry	Protein biochemistry & structural biology
Julie Oxford	Co-PI – Dist. Prof. Biology	Matrix Biology; protein biochemistry
Jim Browning	Co-PI – Prof. Comp. Elect. Engineering	Food safety / food security
JoAnn Lighty	Co-PI – Prof. Mech. Biomed. Engineering	Chemical engineering – kinetics
Priscila Santiago	Postdoc – Food Engineering	PEF treatment of food & beverage
Marcus Pearlman	PostDoc – Food Engineering	Plasma Treatment of bacteria
Joseph Collins	BMOL Ph.D. student	Dairy proteins / BUILD Dairy
Ranajoy Bhattacharya	Postdoc – Food Engineering	Microwave Detection of bacteria
Jared Seale	CHEM MS student	Food toxicity / poisonous plants
Sam Robinette	CHEM BS student	Potato chip acrylamide reduction
Madison Dirks	BMOL Ph.D. student	Dairy protein bioactivity / BUILD Dairy
Elizabeth Ryan	BMOL Ph.D. student	PEF treatment of food & beverage
Rose Saxton	Research Technician	Dairy protein & PEF wine
Mark Skinner	MSMSE Ph.D. student	PEF heat/mass transfer kinetics
Jayden Brandt	Research Technician	Food System VIP course coordination
Hayley Shuagis	CHEM BS student	Food toxicity / poisonous plants
Mady Tyndall	CHEM BS student	Dietary supplement safety
Olivia Brown	CHEM BS student	Food toxicity / poisonous plants
Nick Franklin	CHEM BS student	PEF treatment of food & beverage
Ajay Atkinson	CHEM BS student	Smoke potato quality assessment
Emily Garden	INBRE Summer Fellowship	Toxicology studies of Tianaa
Matt Lorentz	CHEM BS student	PEF wine studies
Kiana Mohammadi	HS student	Dairy GMP ingredient studies
Diane Smith	Grant Administrator	Meeting minutes and progress reports
Tracy Yarnell	Website Designer	Creation of FDICenter website
Eric Baggs	Postdoc – Protein Biochemistry	Protein biochemistry/Isolation
Gulhan Unlu	UI Associate Professor	Dairy microbiology
Josh Bevan	UI Director Food Technology Center	Potato processing and barley malting
Mike Thornton	UI Professor	Potato growth trials
Joe Guenther	UI Emeritus Professor	Potato economic analysis
Carolyn Bohach	UI Distinguished Professor	INBRE student fellowship support
Sam Minnich	UI Professor	INBRE network meeting coordination

8.0 Future Plans for Project Continuation or Expansion

For FY23, we have hired postdoctoral researcher, Dr. OB Azad, identified additional industry partners to sponsor research activity (Agropur, Glanbia, Daisy Brand, and Clextral) to sustain operations, we will seek external funding for collaborative projects with UI faculty Unlu and Hamlett, and will seek to recruit additional students into food and dairy research and internship programs. Outreach to ISU will be conducted in FY23 with the goal of identifying collaborative activities that draw upon the resources available in the FDIC. Until the FDIC labs are constructed in the MCMR, work will be carried out across FDIC team members' individual spaces. Goals for FY23 include tangible collaborative projects with faculty at UI and ISU, and a continued focus on addressing the needs of Idaho industry. A driver for the FDIC activities is the research experiences for students that provide essential skills for employment. The fall 2022 VIP course will be the primary mechanism to build student competency.

9.0 Commercialization Revenue

Nothing to report.