INSTRUCTION, RESEARCH, AND STUDENT AFFAIRS
JUNE 10, 2020

SUBJECT

Board Policy III.E. Certificates and Degrees – First Reading

REFERENCE

December 2013	Board approved first reading of amendments to Board Policy III.E that included updates to definitions for technical certificates and credit hours.
February 2014	Board approved the second reading of amendments to Board Policy III.E.
June 2018	Board approved the first reading of amendments to Board Policy III.E.
February 2019	Board approved first reading of amendments to Board Policy III.E due to changes between readings. This included a definition of an applied baccalaureate degree and a definition of microcertifications.
April 2019	Board approved second reading of amendments to Board Policy III.E.

APPLICABLE STATUTES, RULE OR POLICY

Idaho State Board of Education Governing Policies & Procedures, Section III.E.

BACKGROUND/DISCUSSION

Board Policy III.E. provides definitions for approved certificates and degrees, including credit requirements for career technical education programs and academic programs. The proposed amendment adds a definition of a specialized certificate that would provide individuals that already hold a certificate or degree with opportunities to further develop and/or upgrade skills in an occupation.

IMPACT

The proposed amendment will distinguish a specialized certificate from the current academic, basic, intermediate, and advanced technical certificates currently defined in Board Policy III.E. The amendment will provide institutions with flexibility in developing proficiencies that move beyond basic and intermediate levels.

ATTACHMENTS

Attachment 1 – Board Policy III.E. Certificates and Degrees – First Reading

STAFF COMMENTS AND RECOMMENDATIONS

Idaho Division of Career Technical Education and the Technical College Leadership Council have identified a need to develop a specialized certificate that will recognize specific industry needs. The certificate would be awarded for completion of specific courses that have been industry validated and sequenced for the purpose of developing and upgrading skills in an occupation.

The Council on Academic Affairs and Programs reviewed the proposed policy amendments at their April 2, 2020 meeting. The Instruction, Research, and

Student Affairs Committee reviewed the proposed amendment at its May 28, 2020 meeting.

BOARD ACTION

I move to approve the first reading of the proposed amendment to Board policy III.E. Certificates and Degrees as submitted in Attachment 1.

Moved by __________ Seconded by __________ Carried Yes _____ No _____

Idaho State Board of Education

GOVERNING POLICIES AND PROCEDURES

SECTION: III. POSTSECONDARY AFFAIRS
SUBSECTION: E. Certificates and Degrees ~~April 2019~~ August 2020

1. Definitions

   Programs of instruction require specified numbers of credits earned through educational work on the part of students. Completion of the program of instruction results in the awarding of a certificate to or conferring of a degree upon the student by the faculty and the Chief Executive Officer. The following definitions have been approved by the Board:

   a. CERTIFICATES:

      i. Academic Certificate of Completion
      A credential awarded for completion of a coherent program of study consisting of six (6) semester credits or less, representing a coherent body of knowledge that does not lead to an academic undergraduate certificate or a degree.

      ii. Academic Undergraduate Certificate
      A credential awarded for completion of a coherent program of study consisting of seven (7) semester credits or more, representing a coherent body of knowledge that may lead to an academic degree.

      iii. Graduate Certificate
      A credential awarded for completion of a coherent program of study consisting of nine (9) or more semester credits of graduate course work, representing a coherent body of knowledge that may lead to a degree or may be unique and standalone.

      iv. Technical Certificate of Completion
      A career technical credential awarded by the institution consisting of seven (7) semester credits or less that represents mastery of a defined set of competencies.

      v. Basic Technical Certificate
      A credential awarded for completion of requirements in an approved career technical program of at least eight (8) semester credit hours and represents mastery of a defined set of competencies.

      vi. Intermediate Technical Certificate
      A credential awarded for the completion of requirements in an approved career technical program of at least 30 semester credit hours and represents mastery

of a defined set of competencies.

vii. Advanced Technical Certificate
A credential awarded for completion of requirements in an approved career technical program of at least 52 semester credit and represents mastery of a defined set of competencies.

viii. Microcertification
A credential in a narrowly focused area within career technical program or academic program that confirms mastery through a formal assessment of a specific industry-related skillset or topic. Completion of multiple microcertification courses may lead to a certificate.

ix. Specialized Certificate
A credential awarded upon successful completion of specific courses that have been industry validated and sequenced for the purpose of developing and upgrading skills in an occupation.

b. ASSOCIATE OF APPLIED SCIENCE DEGREE: A credential awarded for completion of requirements in an approved career technical program of at least 60 semester credits (includes a minimum of 15 general education credits) and represents mastery of a defined set of competencies. An Advanced option may be awarded for additional credits of at least 15 credit hours that are beyond the A.A.S. degree.

c. ASSOCIATE DEGREE: A credential awarded for completion of requirements entailing the equivalent of at least 60 semester credits of academic work. An Associate Degree shall not require more than 60 semester credits unless necessary for matriculation to a specific baccalaureate program or for unique accreditation, certification, or professional licensure purposes or by exception approved by the Board.

d. BACCALAUREATE DEGREE: A credential awarded for completion of requirements entailing the equivalent of at least 120 semester credits of academic work. A baccalaureate degree shall not require more than 120 semester credits unless needed for unique accreditation, certification, professional licensure purposes, or by exception approved by the Board.

e. APPLIED BACCALAUREATE DEGREE: A credential awarded for completion of requirements entailing the equivalent of at least 120 semester credits of academic and career technical coursework (includes a minimum of 36 general education credits). An applied baccalaureate degree shall not require more than 120 semester credits unless needed for unique accreditation, certification, or professional licensure purposes or by exception approved by the Board.

f. GRADUATE DEGREES: A credential awarded for completion of academic work beyond the baccalaureate degree, including any required research. Graduate degrees consist of master's degrees, specialist degrees, and doctoral degrees.

2. Academic and Career Technical Credit Hour Requirements

A credit hour is an amount of work represented in intended learning outcomes and verified by evidence of student achievement that is an institutionally established equivalency that reasonably approximates not less than:

a. One (1) hour of classroom or direct faculty instruction and a minimum of two hours of out-of-class student work each week for approximately fifteen weeks for one semester hour of credit, or ten to twelve weeks for one quarter hour of credit, or the equivalent amount of work over a different amount of time; or

b. At least an equivalent amount of work as required in paragraph (a) of this definition for other academic activities as established by the institution, including laboratory work, internships, practica, studio work, and other academic work leading to the award of credit hours.

3. Requirements for Certificate or Degree

Each institution will establish the number of earned credits required for each certificate or degree. The requirements may differ from the general requirements specified in the definitions in subsection 1; however, all credit requirements must receive Board approval in accordance with the program approval policies provided in III.G. Institutional catalogs will specify the required number of earned credits for each certificate or degree.

4. Authorization Required

Programs offered at the institution, as well as the certificates and degrees to which they lead, are subject to review and approval in accordance with the program approval policies provided in III.G. A certificate or degree conferred upon the student is conferred under the authority of the Board.

5. Authorized Certificates and Degrees

   A current listing of authorized certificates and degrees awarded by each institution is maintained at the institution by the Chief Executive Officer and for all institutions at the Office of the State Board of Education.

6. Honorary Degrees

   Each institution may award honorary degrees, not to exceed the highest level of Board-authorized degrees currently awarded by the institution, to persons in recognition of distinguished achievements at the local, state, or national level in areas such as education, public service, research, sciences, humanities, business, or other professions. The award of an honorary degree must receive the prior approval of the Chief Executive Officer upon recommendation by the faculty.

   Each institution will develop its own procedures for seeking nominations for and selecting honorary degree recipients. Those procedures may include a statement of eligibility requirements for honorary degrees. However, no person who is currently employed by the institution, is a member of the Board or the Board's staff, or is an incumbent elected official is eligible for an honorary degree during the term of employment, appointment, or office.

SUBJECT

Board Policy III.Z, Planning and Delivery of Postsecondary Programs and Courses – First Reading

REFERENCE

October 20, 2016	The Board approved the first reading of the proposed amendments to Board Policy III.Z that updates institutions' statewide program responsibilities.
December 15, 2016	The Board approved the second reading of proposed amendments to Board Policy III.Z. that updates institutions' statewide program responsibilities.
December 21, 2017	The Board approved the first reading of proposed amendments to Board Policy III.Z that changes the planning timeframe from five years to three years.
February 15, 2018	The Board approved the second reading of proposed amendments to Board Policy III.Z.
June 21, 2018	The Board approved the first reading of proposed amendments to Board Policy III.Z. adding responsibilities for applied baccalaureate degrees to each region.
August 16, 2018	The Board approved the second reading of proposed amendments to Board Policy III.Z.

APPLICABLE STATUTE, RULE, OR POLICY

Idaho State Board of Education Governing Policies and Procedures, Section III.Z Planning and Delivery of Postsecondary Programs and Courses.
Idaho State Board of Education Governing Policies and Procedures, Section III.G Postsecondary Program Approval and Discontinuance
Section 33-113, Idaho Code.
Section 33-2107A, Idaho Code.

BACKGROUND/DISCUSSION

The purpose of Board Policy III.Z. is to ensure all of Idaho's public postsecondary institutions meet the educational and workforce needs of the state through program planning, alignment, collaboration and coordination, and to meet the statutory requirement to "as far as practicable prevent wasteful duplication of effort" by the institutions.

Board Policy III.Z. outlines the process and procedures for the planning and delivery of Statewide and Regional Programs based on service region and statewide program responsibilities. The Board established statewide program responsibilities that are degree and program specific for the University of Idaho, Idaho State University, and Boise State University. These program responsibilities are contained in Board Policy III.Z. for each institution. Currently Board Policy III.G, which provides the procedures for program approval, includes a provision to require Board review and approval of changes to program names or degree titles related to Statewide Program Responsibilities outlined in Board Policy III.Z. The University of Idaho has submitted notification to the Board office of their intent to change the name of their existing B.S. “Renewable Materials” program to “Forest and Sustainable Products”, which is currently a statewide program responsibility.

ATTACHMENTS

Attachment 1 – First Reading, Planning and Delivery of Postsecondary Programs and Courses
Attachment 2 – University of Idaho Letter of Notification for Name Change

STAFF COMMENTS AND RECOMMENDATIONS

To better track program changes and ensure alignment of statewide program responsibilities provided in Board Policy III.Z, a provision was added to Board Policy III.G Postsecondary Program Approval and Discontinuance, requiring institutions to submit in writing any changes to program names or degree titles of statewide programs listed in policy. The proposed change would essentially revert the program name of “Renewable Materials” back to its original name of “Forest and Sustainable Products”. The proposed change would make the program name consistent with industry standards and more marketable and identifiable to prospective students.

The proposed amendment was presented to the Council on Academic Affairs and Programs on May 14, 2020; and to the Instruction, Research, and Student Affairs Committee on May 28, 2020.

Staff recommends approval.

BOARD ACTION

I move to approve the first reading of proposed amendments to Board Policy III. Z., Planning and Delivery of Postsecondary Education, as submitted in Attachment 1.

Moved by __________ Seconded by __________ Carried Yes _____ No _____

ATTACHMENT 1

Idaho State Board of Education
GOVERNING POLICIES AND PROCEDURES
SECTION: III. POSTSECONDARY AFFAIRS
Subsection: Z. Planning and Delivery of Postsecondary Programs and Courses
August 2018

The purpose of this policy is to ensure Idaho's public postsecondary institutions meet the educational and workforce needs of the state through academic planning, alignment of programs and courses (hereinafter referred to collectively as "programs"), and collaboration and coordination. This subsection shall apply to the University of Idaho, Boise State University, Idaho State University, Lewis-Clark State College, College of Eastern Idaho, College of Southern Idaho, College of Western Idaho, and North Idaho College (hereinafter "institutions"). The State Board of Education (the Board) aims to optimize the delivery of academic programs while allowing institutions to grow and develop consistent with their vision and mission with an appropriate alignment of strengths and sharing of resources.

This policy requires the preparation and submission of academic plans to advise and inform the Board in its planning and coordination of educational programs in a manner that enhances access to quality programs, while concurrently increasing efficiency, avoiding unnecessary duplication and maximizing the cost-effective use of educational resources. As part of this process, the Board hereby identifies and reinforces the responsibilities of the institutions governed by the Board to deliver Statewide Programs. The provisions set forth herein serve as fundamental principles underlying the planning and delivery of programs pursuant to each institution's assigned Statewide and Service Region Program Responsibilities. These provisions also require collaborative and cooperative agreements, or memorandums of understanding, between and among the institutions.

This policy is applicable to campus-based face-to-face programs, including those that use technology to facilitate and/or supplement a physical classroom experience. It also applies to hybrid and blended programs where a substantial portion of the content is delivered on-line and typically has reduced seat time.

1. Definitions

    a. Designated Institution shall mean an institution whose main campus is located in a service region as identified in subsection 2.b.ii.1) and 2) below.

        i. For purposes of this policy, with respect to academic programs, Designated Institutions and Partnering Institutions shall have Service Region Program Responsibility for those regions identified in subsection 2.b.ii.1).

        ii. For purposes of this policy, with respect to career technical programs, Designated Institutions and Partnering Institutions shall include only the College of Southern Idaho, College of Western Idaho, North Idaho College, College of Eastern Idaho, Lewis-Clark State College, and Idaho State University and shall have Service Region Program Responsibility for those regions identified in subsection 2.b.ii.2).

b. A memorandum of understanding (MOU) is an agreement between two or more institutions offering programs within the same service region that details how such programs will be delivered in a collaborative manner. An MOU is intended to provide specific, practical details that build upon what has been provided in each Institution's Plan.

c. Partnering Institution shall mean either (i) an institution whose main campus is located outside of a Designated Institution's identified service region but which, pursuant to a Memorandum of Understanding, offers Regional Programs in the Designated Institution's primary service region, or (ii) an institution not assigned a Statewide Program Responsibility which, pursuant to a Memorandum of Understanding with the institution assigned the Statewide Program Responsibility, offers and delivers a statewide educational program.

d. Service Region Program shall mean an educational program identified by the Board to be delivered by a Designated Institution within its respective service region that meets regional educational and workforce needs.

e. Service Region Program Responsibility shall mean an institution's responsibility to offer and deliver a Service Region Program to meet regional educational and workforce needs in its primary service region as defined in subsection 2.b.ii.1) and 2) below. Service Region Program Responsibilities are assigned to the Designated Institution in each service region, but may be offered and delivered by Partnering Institutions in accordance with the procedures outlined in this policy.

f. Statewide Program shall mean an educational program identified by the Board to be delivered by a particular institution which meets statewide educational and workforce needs. Lewis-Clark State College, College of Eastern Idaho, North Idaho College, College of Southern Idaho, and College of Western Idaho do not have Statewide Program Responsibilities.

g. Statewide Program Responsibility shall mean an institution's responsibility to offer and deliver a Statewide Program in all regions of the state. Statewide Program Responsibilities are assigned to a specific institution by the Board, taking into account the degree to which such program is uniquely provided by the institution.

2. Planning and Delivery Process and Requirements

a. Planning

i. Three-Year Plan

The Board staff shall, using the Institution Plans submitted, create and maintain a rolling three (3) year academic plan (Three-Year Plan) which includes all current and proposed institution programs. The Three-Year Plan shall be approved by the Board annually at its August Board meeting.

ii. Institution Plan

Each institution shall, in accordance with a template to be developed by the Board's Chief Academic Officer, create and submit to Board staff a rolling three (3) year academic plan, to be updated annually, that describes all current and proposed programs and services to be offered in alignment with each institution's Statewide and Service Region Program Responsibilities (the Institution Plan). Institution Plans shall be developed pursuant to a process of collaboration and communication with the other institutions in the state.

1) Statewide Programs

Institutions assigned a Statewide Program Responsibility shall plan for and determine the best means to deliver such program. Each institution assigned a Statewide Program Responsibility shall include in its Institution Plan all currently offered and proposed programs necessary to respond to the workforce and educational needs of the state relating to such Statewide Program Responsibilities. Each Institution Plan shall include the following information for proposed Statewide programs:

a) A description of the Statewide Programs to be delivered throughout the state and the anticipated resources to be employed.

b) A description of the Statewide Programs to be offered by a Designated or Partnering Institution.

c) A summary of the Memoranda of Understanding (MOU's), if any, to be entered into with Partnering Institutions pursuant to Subsection 2.b.iii. below.

2) Service Region Programs

It is the responsibility of the Designated Institution to plan for and determine the best means to deliver Service Region Programs that respond to the educational and workforce needs of its service region. If, in the course of developing or updating its Institution Plan, the Designated Institution identifies a need for the delivery of a program within its service region, and the Designated Institution is unable to provide the program, then the Designated Institution shall coordinate with a Partnering Institution (including institutions with Statewide Program Responsibilities if applicable) located outside of the service region to deliver the program in the service region.

The Institution Plan developed by a Designated Institution shall include the following:

a) A description of the proposed academic programs to be delivered in the service region, or outside of the service region, by the Designated Institution and the anticipated resources to be employed.

b) A description of proposed programs to be offered in the service region by Partnering Institutions, including any anticipated transition of programs to the Designated Institution.

c) A description of proposed Statewide Programs to be offered in the service region by an institution with Statewide Program Responsibilities, or by the Designated Institution in coordination with the institution holding the Statewide Program Responsibility.

d) A summary of proposed MOU's, if any, to be entered into between the Designated Institution and any Partnering Institutions in accordance with Subsection 2.b.iii. below.

3) Institution Plan Updates

Institution Plans shall be updated and submitted to Board staff annually as follows:

a) Preliminary Institution Plans shall be developed according to a template provided by the Board's Chief Academic Officer and submitted to the Council for Academic Affairs and Programs (CAAP) for review, discussion and coordination annually in April.

b) Following review by CAAP, Institution Plans shall be submitted to Board staff. Upon submission of the Institution Plans to Board staff, the Board's Chief Academic Officer shall review the Institution Plans for the purpose of optimizing collaboration and coordination among institutions, ensuring efficient use of resources, and avoiding unnecessary duplication of programs.

c) In the event the Board's Chief Academic Officer recommends material changes, he/she shall work with the institutions and then submit those recommendations to CAAP for discussion prior to submission to the Board for inclusion in the Three-Year Plan.

d) The Board's Chief Academic Officer shall then provide their recommendations to the Board for enhancements, if any, to the Institution Plans at a subsequent Board meeting. The Board shall approve the Institution Plans annually through the Three-Year Plan submitted by Board staff. Board approval of Institution Plans acts as a roadmap for institutional planning and does not constitute Board approval of a program. Institutions are still required to follow the standard program approval process as identified in Board Policy Section III.G to gain program approval.

b. Delivery of Programs

i. Statewide Program Delivery
The Board has established statewide program responsibilities for the following institutions. This statewide program list shall be updated by the Board every two years.

Boise State University must assess the need for and, when determined necessary by the assessment, ensure the statewide delivery of all educational programs in the following degree program areas:

Program Name	Degrees
Public Policy and Administration	M.S., Ph.D.
Community and Regional Planning	M.C.R.P., Ph.D.
Social Work (Region V-VI —shared with ISU)	M.S.W.
Social Work	Ph.D.

Idaho State University must assess the need for and, when determined necessary by the assessment, ensure the statewide delivery of all educational programs in the following degree program areas:

Program Name	Degrees
Audiology	Au.D., Ph.D.
Physical Therapy	D.P.T., Ph.D.
Occupational Therapy	M.O.T.
Pharmaceutical Science	M.S., Ph.D.
Pharmacy Practice	Pharm.D.
Nursing (Region III shared w/ BSU)	M.S., D.N.P.
Nursing	Ph.D.
Physician Assistant	M.P.A.S.
Speech Pathology	M.S.

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Program Name	Degrees
Deaf Education	M.S.
Sign Language Interpreting	B.S.
Health Education	M.H.E.
Public Health	M.P.H.
Health Physics	B.S., M.S., Ph.D.
Dental Hygiene	B.S., M.S.
Medical Lab Science	B.S., M.S.
Clinical Psychology	Ph.D.

University of Idaho must assess the need for and, when determined necessary by the assessment, ensure the statewide delivery of all educational programs in the following degree program areas:

Program Name	Degrees
Law	J.D.
Architecture	B.S. Arch., M. Arch.
Integrated Architecture & Design	M.S.
Landscape Architecture	B.S.L.A., M.L.A.
Interior Design	B.I.D., M.S.
Animal & Veterinary Science	B.S.A.V.S.
Animal Science	M.S.
Veterinary Science	D.V.M.
Plant Science	M.S., Ph.D.
Agricultural Economics	B.S.Ag.Econ.
Applied Economics (Agricultural)	M.S.
Food Science	B.S.F.S., M.S., Ph.D.
Forestry	B.S.Forestry
Renewable Materials	B.S.Renew.Mat.
Wildlife Resources	B.S.Wildl.Res.
Fishery Resources	B.S.Fish.Res.
Natural Resource Conservation	B.S.Nat.Resc.Consv.
Rangeland Ecology & Management	B.S.Rangeland.Ecol.Mgmt.
Fire Ecology & Management	B.S.Fire.Ecol.Mgt.
Natural Resource concentrations in: • Forestry • ~~Renewable Materials~~ Forest and Sustainable Products • Wildlife Resources • Fishery Resources • Natural Resource Conservation • Rangeland Ecology & Management • Fire Ecology & Management	M.S., M.N.R., Ph.D.

ii. Service Region Program Delivery

The Board has established service regions for the institutions based on the six geographic areas identified in Section 33-2101, Idaho Code. A Designated Institution shall have the Service Region Program Responsibility to assess and ensure the delivery of all educational programs and services necessary to meet the educational and workforce needs within its assigned service region.

1) Academic Service Regions

Region I shall include the area within Area No.1 under Section 33-2101, Idaho Code. Lewis-Clark State College, the University of Idaho, and North Idaho College are the Designated Institutions serving undergraduate needs. The University of Idaho is the Designated Institution serving the graduate education needs. Lewis-Clark State College, and North Idaho College are the Designated Institutions serving applied baccalaureate degree needs.

Region II shall include the area within Area No.2 under Section 33-2101, Idaho Code. Lewis-Clark State College and the University of Idaho are the Designated Institutions serving undergraduate needs. The University of Idaho is the Designated Institution serving the graduate education needs.

Region III shall include the area within Area No.3 under Section 33-2101, Idaho Code. Boise State University and College of Western Idaho are the Designated Institutions serving undergraduate needs. Boise State University is the Designated Institution serving graduate education needs. Boise State University and College of Western Idaho are the Designated Institutions serving applied baccalaureate degree needs.

Region IV shall include the area within Area No.4 under Section 33-2101, Idaho Code. Idaho State University and College of Southern Idaho are the Designated Institutions serving undergraduate needs. Idaho State University is the Designated Institution serving the graduate education needs, with the exception that Boise State University will meet undergraduate and graduate business program needs. Idaho State University and College of Southern Idaho are the Designated Institutions serving applied baccalaureate degree needs.

Region V shall include the area within Area No.5 under Section 33-2101, Idaho Code. Idaho State University is the Designated Institution serving undergraduate and graduate education needs.

Region VI shall include the area within Area No.6 under Section 33-2101, Idaho Code. Idaho State University and College of Eastern Idaho are the Designated Institutions serving undergraduate education needs. Idaho State University is the Designated Institution serving the graduate education needs. Idaho State University and College of Eastern Idaho are the Designated Institutions serving applied baccalaureate degree needs.

2) Career Technical Service Regions

Postsecondary career technical education is delivered by six (6) institutions, each having responsibility for serving one of the six geographic areas identified in Section 33-2101.

Region I shall include the area within Area No.1 under Section 33-2101, Idaho Code. North Idaho College is the Designated Institution.

Region II shall include the area within Area No.2 under Section 33-2101, Idaho Code. Lewis-Clark State College is the Designated Institution.

Region III shall include the area within Area No.3 under Section 33-2101, Idaho Code. College of Western Idaho is the Designated Institution

Region IV shall include the area within Area No.4 under Section 33-2101, Idaho Code. College of Southern Idaho is the Designated Institution.

Region V shall include the area within Area No.5 under Section 33-2101, Idaho Code. Idaho State University is the Designated Institution.

Region VI shall include the area within Area No.6 under Section 33-2101, Idaho Code. College of Eastern Idaho is the Designated Institution.

3) Program Offerings by Partnering Institutions

If a Partnering Institution (other than an institution with Statewide Program Responsibilities) identifies a Service Region Program not identified, or anticipated to be identified, in a Designated Institution's Plan, and the Partnering Institution wishes to offer such program in the Designated Institution's service region, then the Partnering Institution may communicate with the Designated Institution for the purpose of allowing the Partnering Institution to deliver such program in the service region and to include the program in the Designated Institution's Plan. In order to include the program in the Designated Institution's Plan, the Partnering Institution must demonstrate the need within the service region for delivery of the program, as determined by the Board (or by the Administrator of the Division of Career Technical Education in the case of career technical level programs). In order to demonstrate the need for the delivery of a program in a service region, the Partnering Institution shall complete and submit to the Chief Academic Officer of the Designated Institution, to CAAP and to Board staff, in accordance with a schedule to be developed by the Board's Chief Academic Officer, the following:

a) A study of business and workforce trends in the service region indicating anticipated, ongoing demand for the educational program to be provided.

b) A survey of potential students evidencing demand by prospective students and attendance sufficient to justify the short-term and long-term costs of delivery of such program.

c) A complete description of the program requested to be delivered, including a plan for the delivery of the program, a timeline for delivery of the program, the anticipated costs of delivery, the resources and support required for delivery (including facilities needs and costs), and program syllabuses.

4) Designated Institution's First Right to Offer a Program

In the event the Partnering Institution has submitted the information set forth above to the Board's Chief Academic Officer) for inclusion in the Designated Institution's Plan, and a need is demonstrated by the Partnering Institution for such program in the service region, as determined by the Board (or by the Administrator for the Division of Career Technical Education in the case of career technical level programs), or prior to the submission of an updated Institution Plan by the Designated Institution, it is determined by the Board that an emergency need has arisen for such program in the service region the Designated Institution shall have a first right to offer such program.

The Designated Institution must within six (6) months (three (3) months in the case of associate level or career technical level programs) of receiving the request from a Partnering Institution to offer said program determine whether it will deliver such program on substantially the same terms (with respect to content and timing) described by the Partnering Institution. In the event the Designated Institution determines not to offer the program, the Partnering Institution may offer the program according to the terms stated, pursuant to an MOU to be entered into with the Designated Institution. If the Partnering Institution materially changes the terms and manner in which the program is to be delivered, the Partnering Institution shall provide written notice to the Chief Academic Officer of the Designated Institution and to the Board's Chief Academic Officer of such changes and the Designated Institution shall be afforded the opportunity again to review the terms of delivery and determine within three (3) months of the date of notice whether it will deliver such program on substantially the same terms.

iii. Memoranda of Understanding

When a service region is served by more than one institution for the delivery of an academic or technical credential defined in Board Policy Section III.E., an MOU shall be developed between such institutions as provided herein and submitted to the Board's Chief Academic Officer for review and approval by the Board prior to entering into such agreements. Each MOU shall be entered into based on the following guidelines, unless otherwise approved by the Board.

If an institution with Statewide Program Responsibility has submitted the information set forth in Subsection 2.a.ii. above to a Designated Institution and Board staff in a timely manner (as determined by the Board's Chief Academic Officer) for inclusion in the Designated Institution's Plan, then the Designated Institution shall identify the program in its Institution Plan and enter into an MOU with the institution with Statewide Program Responsibility in accordance with this policy. If, prior to the submission of an updated Institution Plan by the Designated Institution, it is determined by the Board that an emergency need has arisen for such program in the service region, then upon Board approval the institution with Statewide Program Responsibility and the Designated Institution shall enter into an MOU for the delivery of such program in accordance with the provisions of this policy.

iv. Facilities

For programs offered by a Partnering Institution (whether an institution with Statewide Program Responsibilities, or otherwise) within a municipal or metropolitan area that encompasses the campus of a Designated Institution, the Partnering Institution's programs offerings shall be conducted in facilities located on the campus of the Designated Institution to the extent the Designated Institution is able to provide adequate and appropriate property or facilities (taking into account financial resources and programmatic considerations), or in facilities immediately adjacent to the campus of the Designated Institution. Renting or building additional facilities shall be allowed only upon Board approval, based on the following:

1) The educational and workforce needs of the local community demand a

separate facility at a location other than the campus of the Designated Institution or adjacent thereto as demonstrated in a manner similar to that set forth in Subsection 2.b.ii.1) above, and

2) The use or development of such facilities are not inconsistent with the Designated Institution's Plan.

Facilities rented or built by a Partnering Institution (whether an institution with Statewide Program Responsibilities, or otherwise) on, or immediately adjacent to, the "main" campus of a Designated Institution may be identified (by name) as a facility of the Partnering Institution, or, if the facility is rented or built jointly by such institutions, as the joint facility of the Partnering Institution and the Designated Institution. Otherwise, facilities utilized and programs offered by one or more Partnering Institutions within a service region shall be designated as "University Place at (name of municipality)."

For programs offered by a Partnering Institution (whether an institution with Statewide Program Responsibilities, or otherwise) within a municipality or metropolitan area encompassing a campus of a Designated Institution, to the extent programmatically possible, auxiliary services (including, but not limited to, bookstore, conference and other auxiliary enterprise services) and student services (including, but not limited to, library, information technology, and other auxiliary student services) shall be provided by the Designated Institution. To the extent programmatically appropriate, registration services shall also be provided by the Designated Institution. It is the goal of the Board that a uniform system of registration ultimately be developed for all institutions governed by the Board. The Designated Institution shall offer these services to students who are enrolled in programs offered by the Partnering Institution in the same manner, or at an increased level of service, where appropriate, as such services are offered to the Designated Institution's students. An MOU between the Designated Institution and the Partnering Institution shall outline how costs for these services will be allocated.

v. Duplication of Courses

If courses necessary to complete a Statewide Program are offered by the Designated Institution, they shall be used and articulated into the Statewide Program.

vi. Program Transitions

Institutions with Statewide Program or Service Region Program Responsibilities may plan and develop the capacity to offer a program within a service region where such program is currently being offered by another institution (the Withdrawing Institution) as follows:

1) The institution shall identify its intent to develop the program in the next update of its Institution Plan. The institution shall demonstrate its ability to offer the program through the requirements set forth in Subsection 2.b.ii.3) above.

2) Except as otherwise agreed between the institutions pursuant to an MOU, the Withdrawing Institution shall be provided a minimum three (3) year transition period to withdraw its program. If the Withdrawing Institution wishes to withdraw its program prior to the end of the three (3) year transition period, it may do so but in no event earlier than two (2) years from the date of notice (unless otherwise agreed). The Withdrawing Institution shall enter into a transition MOU with the institution that will be taking over delivery of the program that includes an admissions plan between the institutions providing for continuity in student enrollment during the transition period.

vii. Discontinuance of Programs

Unless otherwise agreed between the applicable institutions pursuant to an MOU, if, for any reason, (i) a Designated Institution offering programs in its service region that supports a Statewide Program of another institution, (ii) a Partnering Institution offering programs in the service region of a Designated Institution, or (iii) an institution holding a Statewide Program Responsibility offering Statewide Programs in the service region of a Designated Institution, wishes to discontinue offering such program(s), it shall use its best efforts to provide the institution with Statewide or Service Region Program Responsibility, as appropriate, at least one (1) year's written notice of withdrawal, and shall also submit the same written notice to the Board and to oversight and advisory councils. In such case, the institution with Statewide or Service Region Program Responsibilities shall carefully evaluate the workforce need associated with such program and determine whether it is appropriate to provide such program. In no event will the institution responsible for the delivery of a Statewide or Service Region Program be required to offer such program (except as otherwise provided herein above).

3. Existing Programs

Programs being offered by a Partnering Institution (whether an institution with Statewide Program Responsibilities, or otherwise) in a service region prior to July 1, 2003, may continue to be offered pursuant to an MOU between the Designated

Institution and the Partnering Institution, subject to the transition and notice periods and requirements set forth above.

4. Oversight and Advisory Councils

   The Board acknowledges and supports the role of oversight and advisory councils to assist in coordinating, on an ongoing basis, the operational aspects of delivering programs among multiple institutions in a service region, including necessary resources and support and facility services, and the role of such councils in interacting and coordinating with local and regional advisory committees to address and communicate educational needs indicated by such committees. Such interactions and coordination, however, are subject to the terms of the MOU's entered into between the institutions and the policies set forth herein.

5. Resolutions

   All disputes relating to items addressed in this policy shall be forwarded to the Board's Chief Academic Officer for review. The Board's Chief Academic Officer shall prescribe the method for resolution. The Board's Chief Academic Officer may forward disputes to CAAP and if necessary make recommendation regarding resolution to the Board. The Board will serve as the final arbiter of all disputes.

6. Exceptions

   a. This policy is not applicable to programs for which 90% or more of all activity is required or completed online, or dual credit courses for secondary education.

   b. This policy also does not apply to courses and programs specifically contracted to be offered to a private, corporate entity. However, in the event that an institution plans to contract with a private corporate entity (other than private entities in the business of providing educational programs and course) outside of their Service Region, the contracting institution shall notify the Designated Institutions in the Service Region and institutions with Statewide Program Responsibilities, as appropriate. If the corporate entity is located in a municipality that encompasses the campus of a Designated Institution, the Board encourages the contracting institution to include and draw upon the resources of the Designated Institution insomuch as is possible.

University of Idaho

OFFICE OF THE PROVOST
AND EXECUTIVE VICE PRESIDENT

875 Perimeter Drive MS 3152
Moscow ID 83844-3152

208-885-6448
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provost@uidaho.edu
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March 11, 2020

Patty Sanchez
Academic Affairs Program Manager
Idaho State Board of Education
650 West State Street, Suite #307
P.O. Box 83720
Boise, ID 83720-0037
Patty.sanchez@osbe.idaho.gov

Dear Ms. Sanchez,

The purpose of this Notification Letter is to notify you of changes, per Board Policy III.G.3.d., identified as academic program components. These changes have been fully reviewed and approved at the institutional level. Upon your response, we will notify NWCCU as appropriate. Attachments are in the same order as categorically prepared here.

Names Changes:

- Change the name of the minor in Interior Design to Interior Architecture and Design to align with the change of the major. CIP code is also changing to be the same as the major. No curriculum changes.
- Change the name of the M.A. Teaching English as a Second Language to M.A. Teaching English to Speakers of Other Languages. Program is also moving from the Department of English in the College of Letters, Arts and Social Sciences to the Department of Curriculum & Instruction in the College of Education, Health and Human Sciences. Course changes but no curriculum changes.
- Change the name of the B.S. Renewable Materials to a B.S. in Forest and Sustainable Products. No curriculum changes.

Create New Certificates:

- New Graduate Certificate in Remote Sensing of the Environment
- New Graduate Certificate in Nuclear Decommissioning and Used Fuel Management

Create New Minors:

- Create a new Minor in International Agriculture
- Create a new Minor in Geography

Add an option:

- Add an option to the Masters in Natural Resources of Restoration Ecology and Habitat Management

Discontinuations:

- Discontinue the emphasis History and Literature in the B.S. Music
- Discontinue the Minor in Parks, Protected Areas and Wilderness Conservation

Please do not hesitate to contact me for additional information. We are eager to appropriately notify NWCCU of the delivery location updates in order to make these changes effective in our 2020-21 catalog. Thank you for your assistance.

Sincerely,

Cher C Hendricks

Cher Hendricks
Vice Provost for Academic Initiatives

When will assessment activities occur and at what frequency?

MODIFICATIONS/NAME CHANGES/CIP CODE CHANGES – FILL OUT THIS SECTION IF YOU SELECTED #3 OR #6 ABOVE

Current name of component or degree:	Degree: Renewable Materials (B.S. Renew. Mat.)
New name of component or degree:	Degree: B.S. in Forest and Sustainable Products
Number of credits:	120 to graduate
Describe the modification are you making:	Not applicable
Name of major or degree that the component is attached to:	Not applicable
Describe rationale for the modification:	**Background:** Effective catalog year 2012 program was renamed *Renewable Materials* from *Forest Products* under the rationale that "renaming ... will appeal to broader audience and create new recruitment opportunities" (UCC-12-034). While Renewable Materials embraces the broad scope of raw material resources studied under the degree program, it has been found to be ambiguous/nonspecific and extremely difficult to communicate to prospective students (i.e., high school juniors and seniors) and their parents; a very common response to the name of Renewable Materials is "what is that?" Furthermore, the degree name Renewable Materials created a significant divergence from the primary industry served by the program – forest products – and conflicts with how the industry is identified by other state entities (e.g., Idaho Forest Products Commission, Idaho Department of Commerce, Idaho Department of Labor). Another rational given for the name change to Renewable Materials was that it would increase enrollment by attracting students not otherwise attracted to a program named Forest Products. Enrollment growth did not result from the name change; in fact, it declined. **Name Change:** The proposed change to *Forest and Sustainable Products* returns the degree name back to its roots and makes it consistent with the primary industry it serves. The inclusion of sustainable products captures elements of the program that investigate the use and commercialization of other streams of raw materials (e.g., bamboo, hemp, recycled wood and paper). The name is much more identifiable to prospective students and their parents.

Indicate whether program, curriculum, course and admission requirements remain the same.		Yes – if you select yes to this question, please attach all curriculum and course documents related to this.	X	No
Are any of the learning outcomes changing:		Yes – if yes fill out question below	X	No
List the new learning outcomes:	1. 2. 3. 4. 5.			

DISCONTINUATION – FILL OUT THIS SECTION IF YOU SELECTED #4 OR #5 ABOVE

What are you requesting to discontinue:	

What is the student impact if any?				
Are there curriculum changes needed and/or do new courses need to be created:		Yes – if you select yes to this question, please attach all curriculum and course documents related to this.		No

SIGNATURES – REQUIRED FOR ALL SELECTIONS:

Dept/Unit Curriculum Committee Approval Date:	September 9, 2019	Vote Record:	12/0 (quorum)
Dept Chair Signature of Approval	9/10/2019		
College Curriculum Committee Approval Date:	September 9, 2019	Vote Record:	5/0
Dean Signature of Approval			

FOREST, RANGELAND AND FIRE SCIENCES
College of Natural Resources
875 Perimeter Drive MS 1133
Moscow ID 83844-1133

MEMORANDUM

TO: University Cuuriculum Committee

FROM: Charles Goebel, Department Head PCG

DATE: Spetember 10, 2019

RE: Change of prefix associated with Renewable Materials courses

The College of Natural Resources (CNR) has approved a proposed name change for the Renewable Materials (B.S. Renew. Mat.) degree to Forest and Sustainable Products (B.S. For. Sus. Prod.).

Assuming the proposed name change is approved, CNR is requesting that the prefix associated with all Renewable Materials courses be changed from RMAT to FSP.

SUBJECT

Board Policy III.G, Program Modification Requirements – Partial Waiver

REFERENCE

August 16, 2018	The Board approved the second reading of proposed amendments to Board Policy III.Z, which added the responsibility for delivering applied baccalaureate degrees to the academic service regions.
February 14, 2019	The Board approved the first reading of proposed amendments to include review and approval procedures for applied baccalaureate degrees and microcertifications.
April 18, 2019	The Board approved the second reading of proposed amendments to Board Policy III.G.
August 29, 2019	The Board was presented with a first reading of proposed amendments to Board Policy III.G. Policy was referred back to Instruction, Research, and Student Affairs (IRSA) for additional discussion.
October 17, 2019	The Board approved the first reading of proposed amendments, which adds baccalaureate degree programs to the list of programs reviewed by the Board and changes requirements for new academic program proposals that consists of new state appropriations.
December 2019	The Board approved the second reading of proposed amendments to Board Policy III.G.

APPLICABLE POLICY

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

BACKGROUND/DISCUSSION

Board Policy III.G., Postsecondary Program Approval and Discontinuance, provides Idaho's public institutions with procedures for the development, approval, and discontinuation of academic and career technical programs, including instructional and administrative units.

Currently, Board policy requires completion of a proposal form and approval of modifications to existing academic programs, career technical programs, and instructional and administrative units. These include, but are not limited to, the following program modifications:

- Expansion of an existing program outside a designated service region
- Converting one program option into a stand-alone program
- Consolidating an existing program to create one or more new programs
- Adding a degree or certificate program not already approved by the Board

- Adding courses that represent a significant departure from existing program offerings or method of delivery from those already evaluated and approved by the Board.
- Transitioning existing programs to an online format.
- Changes from clock hours to credit hours or vice versa, or substantial increase or decrease in the length of a program or number of clock or credit hours awarded for successful completion of program.
- Modification of existing programs as provided above resulting from Program Prioritization.
- Reorganizing, merging, and bifurcating existing instructional and administrative units, including moving programs and resources.

Due to current unprecedented conditions and Program Prioritization processes occurring on some campuses, institutions need more streamlined procedures to implement these types of modifications. Staff evaluated Board Policy III.G and identified that procedures could be clarified and proposal requirements for modifications could be simplified. Upon further review of policy III.G., staff noted other areas will also require revision. Rather than modify only portions of Board policy, staff believes that an entire review and revision will be necessary. Additionally, any potential changes will require further discussion with the Council on Academic Affairs and Programs and the Committee on Instruction, Research and Student Affairs before moving forward with amendments.

While those discussions take place and to provide institutions with some immediate assistance, Board approval is requested to temporarily waive the proposal requirement in policy III.G.3.d and 4.d for modifications to academic programs, career technical programs, and instructional and administrative units through June 30, 2021. The exception to this waiver will be the expansion of existing program offerings outside an institution’s designated service region, as defined in Board Policy III.Z. Those types of modifications will continue to require a full program proposal and will be subject to the review and approval process per III.G.

In place of full proposals for the other types of modifications, institutions will supply a letter of request for approval by the Executive Director, provided that the fiscal impact is below $250,000 per fiscal year consistent with policy. The Executive Director will retain the right to request full proposals for modifications as he deems necessary. New programs, discontinuation of programs, and inactivation of programs will continue to require a program proposal or letter of request, as per policy, and will follow the regular process.

IMPACT

Approval of the waiver will allow staff to implement temporary procedures for modifications, and alleviate some burdensome processes for institutions and staff. The waiver will also provide the opportunity to gauge if current procedures and practices could be more streamlined in the long-term.

ATTACHMENTS

Attachment 1 – Board Policy III.Z, Planning and Delivery of Postsecondary Education

STAFF COMMENTS AND RECOMMENDATIONS

Staff is conducting an audit of Board Policy III.G. and has identified several policy requirements that warrant further discussion with the Council on Academic Affairs and Programs (CAAP) and the Instruction, Research and Student Affairs Committee. Implementing this temporary waiver will provide time for staff to conduct a thorough review of the policy and will provide institutions with flexibility in implementing programmatic or structural modifications in light of current unprecedented conditions and budget challenges. Staff will work with CAAP to develop a process for sharing program modifications with institutions as part of this waiver.

The proposed temporary waiver was discussed with the Council on Academic Affairs and Programs on May 14, 2020 and with the Instruction, Research, and Student Affairs Committee on May 28, 2020.

Board staff recommends approval.

BOARD ACTION

I move to waive the requirement for a full proposal in Board Policy III.G.3.d and 4.d for modifications to academic programs, career technical programs, and instructional and administrative units until June 30, 2021. In lieu of a full program proposal requirement, institutions will use the letter of notification process during this time period.

Moved by __________ Seconded by __________ Carried Yes _____ No _____

ATTACHMENT 1

Idaho State Board of Education

GOVERNING POLICIES AND PROCEDURES

SECTION: III. POSTSECONDARY AFFAIRS **December 2019**
SUBSECTION: G. Postsecondary Program Approval and Discontinuance

The Board is responsible for the establishment, maintenance, and general supervision of policies and procedures governing the academic and program affairs of the institutions. This subsection shall apply to the University of Idaho, Idaho State University, Boise State University, Lewis-Clark State College, North Idaho College, College of Eastern Idaho, College of Southern Idaho, and College of Western Idaho.

Program planning shall be a collaborative process which includes the Board, Board staff, the institutions, faculty, external advisory groups, regional and specialized accreditation bodies, and other stakeholders pursuant to Board Policy Section III.Z.

1. Classifications and Definitions

   a. Instructional Unit(s) shall mean departments, institutes, centers, divisions, schools, colleges, campuses, branch campuses, and research units (e.g. extension centers) that are responsible for academic programs or career technical programs.

   b. Administrative Unit(s) shall mean offices, centers, bureaus, or institutes that are responsible for carrying out administrative functions, research, or public service as their primary purpose, and are not responsible for academic or career technical programs.

   c. Academic Program(s) shall mean a systematic, usually sequential, grouping of courses forming a considerable part, or all, of the requirements (i.e., curricula) that provides the student with the knowledge and competencies required in a specialized field (i.e., major) for an academic certificate, an associate's, baccalaureate, master's, specialist, or doctoral degree as defined in Board Policy Section III.E.

   d. Major(s) shall mean a principal field of academic specialization that usually accounts for 25 to 50 percent of the total degree requirements. The concentration of coursework in a subject-matter major serves to distinguish one program from others leading to the same or a similar degree.

   e. Academic Program Components shall include options, minors, emphases, tracks, concentrations, specializations, and cognates as defined by each institution.

   f. Career Technical Program(s) shall mean a sequence or aggregation of competencies that are derived from industry-endorsed outcome standards and directly related to preparation for employment in occupations requiring career technical certificates, microcertifications, or an associate of applied science degree as defined in Board Policy Section III.E. These programs must include competency-based applied learning that contributes to an individual's technical skills, academic knowledge, higher-order reasoning, and problem-solving skills. A course or series of courses leading to a technical certificate of completion is not considered a program for approval purposes.

g. Career Technical Program Components including microcertifications shall mean instructional paths to fields of specialized employment, consisting of more than one specialized course, and may have a separate advisory committee.

h. Financial Impact shall mean the total financial resources, regardless of funding source, needed to support personnel costs, operating expenditures, capital outlay, capital facilities construction or major renovation, and indirect costs that are incurred as a direct result of the new instructional program or modification to an existing program. This includes instructional and administrative units.

2. Roles and Responsibilities

a. Institutions shall establish internal program review processes and procedures. Institutions shall follow their internal review processes and procedures pursuant to Board Policy Section III.H. prior to forwarding proposals to the Board.

b. Program proposals shall be reviewed by the Council on Academic Affairs and Programs (CAAP). CAAP shall make recommendations to the Instruction, Research, and Student Affairs (IRSA) committee on instructional programmatic matters and related policy issues.

c. The Idaho Division of Career Technical Education shall review and make recommendations as appropriate to the IRSA Committee and/or the Board on instructional programmatic matters and policy issues related to their roles and responsibilities. The State Administrator is authorized by the Board to approve academic and career technical microcertifications developed by institutions pursuant to the fiscal impact limits established in subsection 4.b in this policy.

d. The Professional Standards Commission shall review and make recommendations as appropriate to the Board on educator preparation programs.

3. Academic Program Proposal Submission and Approval Procedures

Subsequent to institutional review and consistent with institutional policies, all requests requiring Board or Executive Director approval will be submitted by the institution to Board staff as a proposal in accordance with a template developed by the Board's Chief Academic Officer. Each proposal shall be reviewed by CAAP within 30 days from receipt of said proposal.

a. Branch Campuses - The establishment of a new branch campus or change in location geographically apart from the main campus where the institution offers at least 50% of an education program shall require Board approval regardless of fiscal impact. This subsection of policy excludes community colleges.

b. Learning Outcomes - All postsecondary program approvals will include identifiable learning outcomes and competency measurements for graduates of their programs as defined in Board Policy III.X.

c. Academic Programs
   i. All new, modification of, and/or discontinuation of academic program majors shall require completion of the program proposal prior to implementation. This includes certificates of 30 credits or more; associates, bachelors, masters, specialist, and doctoral degrees; instructional and administrative units. Proposals requiring new state appropriations shall be submitted to the Board for review prior to or concurrently with submission of an institution's annual budget request.

      1) Any program leading to a master's, specialist, or doctoral degree must be approved by the Board prior to implementation. The Instruction, Research and Student Affairs Committee will be notified of baccalaureate degree proposals prior to implementation and may refer them to the Board for review and approval for those it determines appropriate.
      2) Prior to implementation, an institution shall obtain Board approval of any new, modification of and/or discontinuation of academic or career technical programs, including instructional and administrative units with a financial impact of $250,000 or more per fiscal year.
      3) Prior to implementation, an institution shall obtain Executive Director approval of the modification of and/or discontinuation of any academic program; new, modification of, and/or discontinuation of any career technical program; and instructional and administrative units with a financial impact of less than $250,000 per fiscal year.
      3) Pursuant to Section 33-2107A Idaho Code, community colleges shall obtain Board approval of any new applied baccalaureate program regardless of fiscal impact.
      4) Prior to implementation, an institution shall obtain Board approval of any modification and/or discontinuation of all graduate programs leading to a master's, specialist, or doctoral degree regardless of fiscal impact.
      5) The Executive Director may refer any proposal to the Board or subcommittee of the Board for review and action.

ii. Modifications to existing programs shall include, but not limed to, the following:

1) Expanding an existing program outside a designated service region.
2) Converting one program option into a stand-alone program.
3) Consolidating an existing program to create one or more new programs.
4) Adding a degree program not already approved by the Board.
5) Adding courses that represent a significant departure from existing program offerings or method of delivery from those already evaluated and approved by the Board.
6) Transitioning of existing programs to an online format.
7) Changes from clock hours to credit hours or vice-versa, or substantial increase or decrease in the length of a program or number of clock or credit hours awarded for successful completion of program.

iii. Microcertification requests requiring approval will be submitted by the institution to the Division of Career Technical Education (Division) through an approval process in accordance with a template developed by the Division staff. Each request shall be reviewed within 30 days from receipt of request. Academic microcertifications shall be reviewed by Division and Board staff.

1) Prior to implementation, an institution shall obtain State Administrator approval of any new, modification, or discontinuation of a microcertification as defined in Board Policy III.E.
2) Within a microcertification, specific information shall be contained where the microcredential was earned, the detailed criteria required to earn it, the name of the student and the program to ensure the microcredential is specific to the individual who earns it.

iv. All doctoral program proposals shall require an external peer review. The external peer-review panel shall consist of at least two (2) members and will be selected by the Board's Chief Academic Officer and the requesting institution’s Provost. Board staff will notify the institution in writing whether it may proceed with the external peer-review process. External reviewers shall not be affiliated with a public Idaho institution. The review shall consist of a paper and on-site peer review, followed by the issuance of a report and recommendations by the panel. Each institution shall provide the panel with a template developed by the Board’s Chief Academic Officer. The peer reviewer's report and recommendations will be a significant factor of the Board’s evaluation of the program.

v. New educator preparation programs require concurrent submission of the program proposal to the Board office and the Professional Standards Commission (PSC) prior to implementation. The PSC ensures programs meet the Idaho standards for certification. The Board office ensures the program proposal is consistent with the program approval process and meets the standards approved by the Board and established in rule. The PSC makes recommendations to the Board for approval of programs as vehicles for meeting the state certification requirements.

d. Academic Program Components, Program Changes, and Procedures

New, modification, and/or discontinuation of academic program components, and academic undergraduate and graduate certificates of less than thirty (30) credits may require a proposal. For academic program components or certificates requiring a proposal, subsection 3.c.i. of this policy applies.

i. New, modification, and/or discontinuation of academic program components; academic undergraduate and graduate certificates of less than thirty (30) credits and credit changes to existing programs require a formal letter notifying the Office of the State Board of Education prior to implementation of such changes. New academic certificates that require the creation of any new course(s) or resources must provide information in the letter of notification explaining how personnel and fiscal resources will be allocated or reallocated to support the delivery of the new course(s). All letters of notification for new academic certificates must provide the certificate's cost to students, and evidence of the certificate's value to students and workforce needs.

ii. Program name or title changes to degrees, departments, divisions, colleges, or centers; or changes to Classification of Instructional Programs (CIP) codes require a formal letter notifying the Office of the State Board of Education prior to implementation of such changes. Name changes for non-functional purposes are approved pursuant to Board Policy I.K. Naming/Memorializing Building and Facilities.

iii. If the change is judged to be consistent with academic program components and program changes as provided in this section, Board staff will notify the institution in writing that they may proceed with said changes. If the change is determined to be inconsistent with academic program components or the CIP code change represents a significant departure from existing offerings, Board staff will notify the institution in writing and they will be required to complete a program proposal.

iv. Changes to program names or degree titles related to Statewide Program Responsibilities as provided in Board Policy III.Z., must be requested in writing and submitted to Board staff for review and approval by the Board.
v. Minor curriculum changes in a program; descriptions of individual courses; and other routine catalog changes do not require notification or approval.

4. Career Technical Program Proposal Submission and Approval Procedures

All career technical program requests requiring Board or Executive Director approval will be submitted by the institution to the Division of Career Technical Education as a proposal in accordance with a template developed by Board staff. Each proposal shall be reviewed within 30 days from receipt of said proposal. Requests requiring new state appropriations shall be included in the annual budget request of the State Division of Career Technical Education for Board approval.

a. Learning Outcomes
All postsecondary program approvals will include identifiable learning outcomes and competency measurements for graduates of their programs as defined in Board Policy Section III.X.

b. Career Technical Programs and Components

i. All new, modification, and/or discontinuation of career technical programs and components, shall require completion of the program proposal prior to implementation. This includes instructional and administrative units. Career technical program proposals shall be forwarded to the State Administrator of the Division of Career Technical Education for review and recommendation. The State Administrator shall forward the request to CAAP for its review and recommendation. Once CAAP and/or State Administrator recommends approval, the proposal shall be forwarded, along with recommendations, to the Board for action.

1) Prior to implementation, an institution shall obtain Board approval of any new, modification, and/or discontinuation of career technical programs and components with a financial impact of $250,000 or more per fiscal year.
2) Prior to implementation, an institution shall obtain Executive Director approval of any new, modification, and/or discontinuation of career technical programs and components with a financial impact of less than $250,000 per fiscal year.

3) The Executive Director may refer any proposal to the Board for review and action.

ii. Modifications to existing programs shall include, but not be limited to, the following:
   1) Expanding an existing program outside a designated service region.
   2) Converting one program option into a stand-alone program.
   3) Consolidating an existing program to create one or more new programs.
   4) Adding a certificate or degree program not already approved by the Board.
   5) Adding courses that represent a significant departure from existing program offerings or method of delivery from those already evaluated and approved by the Board.
   6) Transitioning of existing programs to an online format.
   7) Changes from clock hours to credit hours or vice-versa, or substantial increase or decrease in the length of a program or number of clock or credit hours awarded for successful completion of program.

iv. Microcertification requests requiring approval will be submitted by the institution to the Division of Career Technical Education through an approval process in accordance with a template developed by Division of Career Technical Education staff. Each request shall be reviewed within 30 days from receipt of request.

   3) Prior to implementation, an institution shall obtain State Administrator approval of any new, modification , or discontinuation of a microcertification as defined in Board Policy III.E regardless of fiscal impact.
   4) Within a microcertification, specific information shall be contained where the microcredential was earned, the detailed criteria required to earn it, the name of the student and the program to ensure the microcredential is specific to the individual who earns it.

c. Career Technical Program Notification Procedures

Program changes to existing career technical programs may require a proposal. For career technical programs requiring a proposal, subsection 4.b.i. of this policy applies.

i. Program name or title changes to degrees, departments, divisions, colleges, or centers; changes to CIP Codes; or credit changes to existing programs require a formal letter notifying the State Administrator prior to implementation of such changes.

ii. If the change is judged to be consistent with program changes as provided in this section, the State Administrator will notify the institution in writing that they may proceed with said changes. If the change is determined to be inconsistent with definition of program components, the State Administrator will notify the institution in writing and they will be required to complete the program proposal.

iii. Minor changes to courses within a current program (e.g., course number, title, description, addition, deletion, and/or credit hours) must be submitted to the State Division of Career Technical Education.

d. Career Technical Program Inactivation

i. The purpose of a career technical program inactivation is to respond to rapid changes in industry demand, allowing time for program assessment and inactivation. If industry demand for the program does not resume within three years following the inactivation, the program shall be discontinued.

ii. Program inactivation requires a formal letter notifying the State Administrator requesting inactivation. The letter will include:

1) Description and rationale for the modification
2) Implementation date
3) Arrangement for enrolled students to complete the program in a timely manner
4) Impact of accreditation, if any
5) Impact to current employees of the program
6) Impact on current budget

iii. The State Administrator will make a recommendation in writing to the Board office. The Board office will send notification to the institution.

iv. Program re-activation requires a formal letter notifying the State Administrator requesting re-activation.

5. Sunset Clause for Program Approval

Academic and career technical education programs approved by the Board or Executive Director must be implemented within five years. A program not implemented within five years from the approval date requires submission for approval of an updated proposal. Institutions shall notify the Board office in writing when an approved program has not been officially implemented. Institutions may request a change in the sunset timeframe indicated in the program proposal if a program's implementation is delayed for any reason.

6. Academic and Career Technical Program Proposal Denial Procedures

   a. The Executive Director shall act on any request within thirty (30) days.

   b. If the Executive Director denies the proposal he/she shall provide specific reasons in writing. The institution shall have thirty (30) days in which to address the issue(s) for denial of the proposal. The Executive Director has ten (10) working days after the receipt of the institution's response to re-consider the denial. If the Executive Director denies the request after re-consideration, the institution may send its request and the supporting documents related to the denial to the Board for final reconsideration.

7. Program Discontinuance

   The primary considerations for instructional program discontinuance are whether the instructional program is an effective use of the institution's resources, no longer serves student or industry needs, or when programs no longer have sufficient students to warrant its allocation. This policy does not apply to instructional programs that are discontinued as a result of financial exigency as defined in Board Policy Section II.N.

   For career technical program discontinuance, institutions shall adhere to criteria and procedures as provided in IDAPA 55.01.02.

   a. Students - Institutions shall develop policies, in accordance with the Northwest Commission on Colleges and Universities Accreditation Handbook, which requires institutions to make appropriate arrangements for enrolled students to complete affected programs in a timely manner with minimum interruptions.

   b. Employees - Any faculty or staff members whose employment the institution seeks to terminate due to the discontinuance of a program based upon Board Policy Section III.G. shall be entitled to the following procedures:

      i. Non-classified contract employees, including non-tenured faculty, may be dismissed or have their contracts terminated or non-renewed in accordance with Board and institutional policies.

ii. State of Idaho classified employees shall be subject to layoff as provided in the rules of the Division of Human Resources. Classified employees of the University of Idaho shall be subject to layoff as provided in the policies of the University of Idaho.

iii. Tenured faculty will be notified in writing that the institution intends to dismiss them as a result of program discontinuance. This notice shall be given at least twelve (12) months prior to the effective date of termination.

iv. An employee who receives a notice of termination as a result of program discontinuance is entitled to use the internal grievance procedures of the institution. The sole basis to contest a dismissal following a program closure is in compliance with these policies.

8. Reporting

   a. The Office of the State Board of Education shall report biannually to the State Board of Education all program approvals and discontinuations approved by the Executive Director.

   b. All baccalaureate and graduate level programs approved by the State Board of Education require a report on the program's progress in accordance with a timeframe and template developed by the Board's Chief Academic Officer.

SUBJECT

Board Policy III.Q. Admission Standards – Waiver of College Entrance Exam Admission Requirement

REFERENCE

December 2008	Information item presented to Board on the formation of a Task Force to examine alternative approaches for placement of students into first-year writing courses (English 90, 101, and 102).
December 2010	Waiver of Board Policy III.Q.4.C., for placement in entry-level college English courses to permit pilots to establish alternative placement mechanisms for English.
February 2013	The Board approved a waiver of Board Policy III.Q.4.c to permit alternative placement mechanisms that are in alignment with the Complete College Idaho plan until the beginning of Fall 2014.
February 2014	The Board approved a waiver of Board Policy III.Q.4.c until the beginning of Fall 2015 to permit the continued development of alternative placement mechanisms.
October 2015	The Board extended the waiver of the criteria in Board policy III.Q.4.c for placement in entry-level college courses one final time to allow for the creation and adoption of alternative placement mechanisms until the end of the Fall semester 2016.
March 2020	The Board waived the college entrance exam as graduation requirement for students graduating in 2020 as a response to the coronavirus pandemic.

APPLICABLE POLICY

Idaho State Board of Education Governing Policies & Procedures, Section III.Q,

BACKGROUND/DISCUSSION

Board Policy III.Q. Admission Standards provides the minimum requirements for admission to Idaho's public colleges and universities. Institutions have established policies that meet the minimum admission standards; however, institutions may establish standards that exceed Board approved minimum standards. The College of Eastern Idaho, College of Southern Idaho, College of Western Idaho and North Idaho College are exempted from certain provisions of the policy when established by their local boards of trustees. None of these two-year colleges currently require a college entrance exam score for admissions decisions.

At the Board's March 27, 2020 meeting, the Board approved a waiver of the college entrance exam graduation requirement in IDAPA 08.02.03.105 for students graduating in 2020. Currently, Board Policy III.Q.4.a, requires all students to submit a college entrance exam score as a requirement for regular admission to the four-year institutions. Acceptable college entrance exams include the American College Test (ACT), the Scholastic Aptitude Test (SAT), and/or other standardized diagnostic tests as determined by the institution. In light of the national pandemic crisis and the resulting cancelation of the national test days by College Board and ACT(?), a waiver of the college entrance exam admissions requirement for students seeking admission to Idaho institutions for the 2020-2021 academic year is necessary to provide immediate assistance to impacted Idaho students.

IMPACT

Approval of the waiver will allow institutions flexibility to determine whether to require college entrance exam scores or not, as the policy allows institutions to implement admissions standards that exceed minimum standards. This action by the Board will allow institutions to provide prospective Idaho students with clear expectations regarding admission requirements for the 2020-2021 academic year.

ATTACHMENTS

Attachment 1 - Board Policy III.Q. Admissions Standards

STAFF COMMENTS AND RECOMMENDATIONS

The proposed waiver was discussed with the Council on Academic Affairs and Programs and was supported at their May 14, 2020 meeting. If the Board approves the waiver, some Idaho institutions may choose to not require college entrance exam scores from students seeking admission in the 2020-2021 academic year. These students will still be required to meet other college entrance requirements as set forth by Board and institutional policies, including the requirement to submit college entrance exam scores if so required by an institution.

The proposed temporary waiver was presented to the Instruction, Research and Student Affairs Committee on May 28, 2020. Staff recommends approval.

BOARD ACTION

I move to waive Board Policy III.Q.4.a, the college entrance exam score as an Idaho public postsecondary minimum admissions requirement, for students seeking admission for the 2020-2021 academic year.

Moved by __________ Seconded by __________ Carried Yes _____ No _____

ATTACHMENT 1

Idaho State Board of Education
GOVERNING POLICIES AND PROCEDURES
SECTION: III. POSTSECONDARY AFFAIRS
SUBSECTION: Q. Admission Standards **June 2017**

1. Coverage

   University of Idaho, Boise State University, Idaho State University, Lewis-Clark State College, College of Eastern Idaho, College of Southern Idaho, College of Western Idaho and North Idaho College are included in this subsection. The College of Eastern Idaho, College of Southern Idaho, College of Western Idaho and North Idaho College are exempted from certain provisions of this admission policy when established in by their local boards of trustees.

2. Purposes

   The purposes of the admission policies are to:

   a. Promote institutional policies which meet or exceed minimum statewide standards for admission to higher education institutions;

   b. Inform students of the academic and technical degree expectations of postsecondary level work;

   c. Improve the quality of academic and technical degree preparation for postsecondary programs;

   d. Enhance student access to academic and technical degree programs; and

   e. Admit to postsecondary education institutions those students for whom there is a reasonable likelihood of success.

3. Policies

   The college and universities must establish institutional policies which meet or exceed the following minimum admission standards. Additional and more rigorous requirements also may be established by the college and universities for admission to specific programs, departments, schools, or colleges within the institutions. Consistent with institutional policies, admission decisions may be appealed by applicants to the institutional admissions committee.

4. Academic College and University Regular Admission

   Students attending an Idaho public school may be notified of their admission to an Idaho public college or university through the State Board's Direct Admission Program. Admission awarded through the program is contingent upon verified level of achievement in high school curriculum and performance on a college entrance exam, and successful completion of state high school graduation requirements.

An applicant who is not admitted under the State board's Direct Admission Program must complete each of the minimum requirements listed below. International students and those seeking postsecondary career technical studies are exempt.

a. Submit scores received on the American College Test (ACT) or Scholastic Aptitude Test (SAT) and/or other standardized diagnostic tests as determined by the institution. These scores will be required of applicants graduating from high school in 1989 or later. Exceptions include applicants who have reached the age of 21. These applicants are subject to each institution's testing requirements; and

b. Graduate from an accredited high school and complete the courses below with a minimum 2.00 cumulative grade point average. Applicants who graduate from high school prior to 1989 will be subject to the admission standards at the time of their graduation.

Admission Standards Core

Subject Area	Minimum Requirement	Select from These Subject Areas
Secondary Language Arts and Communication	8 credits	Composition, Literature, Oral Communication
Mathematics	6 credits	A minimum of six (6) credits, including Applied Math I or Algebra I; Geometry or Applied Math II or III; and Algebra II. A total of 8 credits are strongly recommended. Courses not identified by traditional titles, i.e., Algebra I or Geometry, may be used as long as they contain all of the critical components (higher math functions) prescribed by the State Mathematics Achievement Standards. Other courses may include Probability, Discrete Math, Analytic Geometry, Calculus, Statistics, and Trigonometry. Four (4) of the required mathematics credits must be taken in the 10^{th}, 11^{th}, and 12^{th} grade.
Social Studies	5 credits	American Government (state and local), Geography, U.S. History, and World History. Other courses may be selected from Economics (Consumer Economics if is aligns to the state content standards), Psychology, and Sociology.

Science	6 credits	Anatomy, Biology, Chemistry, Earth Science, and Geology. Physiology, Physics, Physical Science, Zoology. A maximum of two (2) credits may be derived from career technical science courses when courses are aligned to state career technical content standards, and/or Applied Biology, and/or Applied Chemistry. (Maximum of two (2) credits). Must have laboratory science experience in at least two (2) credits. A laboratory science course is defined as one in which at least one (1) class period per week is devoted to providing students with the opportunity to manipulate equipment, materials, or specimens; to develop skills in observation and analysis; and to discover, demonstrate, illustrate, or test scientific principles or concepts.
Arts and Humanities (including world languages)	2 credits	Literature, History, Philosophy, Fine Arts (if the course is aligned to the state arts and humanities content standards), and inter-disciplinary humanities (related study of two or more of the traditional humanities disciplines). History courses beyond those required for state high school graduation may be counted toward this category. World Language is strongly recommended. The Native American Languages may meet the world language credit requirement
Other College Preparation	3 credits	Speech or Debate (no more than one (1) credit). Debate must be taught by a certified teacher. Studio/Performing Arts (art, dance, drama, and music). Foreign Language (beyond any foreign language credit applied in the Humanities/Foreign Language category). Career Technical Education classes (no more than two (2) credits) in Agricultural science and technology, business and office education, health occupations education, family and consumer sciences education, occupational family and consumer sciences education, technology education, marketing education, trade, industrial, and technical education, and individualized occupational training.

If the high school the student graduated from does not offer a required course, applicants may contact the institutional admission officer for clarification of provisional admission procedures.

High school credit counted in one (1) category (e.g., Humanities/World Languages) may not count in another category.

5. Academic College and University Provisional Admission

   a. A degree-seeking applicant who does not qualify for admission based on 4.b above but who satisfies one (1) of the criteria below, seek provisional admission by petitioning the institutional admission director.

      i. Graduated from an accredited secondary school but has not completed the Admission Standards Core set forth above;

      ii. Did not graduate from an accredited secondary school, including home schooled students and has acceptable performance on either the General Educational Development (GED) Test or another standardized diagnostic tests such accepted by the institutions.

      iii. Deserves special consideration by the institution, e.g., disadvantaged or minority students, delayed entry students, returning veterans, or talented students wishing to enter college early.

      A student seeking provisional admission to any public postsecondary institution must take at least two (2) testing indicators that will allow the institution to assess competency and placement, one (1) of which must be the ACT or SAT. ACT or SAT scores must be submitted prior to enrollment.

   b. If provisionally admitted, a student will enroll with provisional standing and is subject to the institutional grade retention. A provisionally admitted student may change to regular admission status upon satisfactory completion of fourteen (14) baccalaureate level credits, twelve (12) of which must be general education courses. Regular admission status must be attained within three (3) registration periods or the student will be dismissed, subject to institutional committee appeal procedures.

6. Advanced Opportunities

   Secondary students who wish to participate in the Advanced Opportunities outlined in Board Policy Section III.Y. Advanced opportunities, must follow the procedures outlined in Board Policy III.Y.

7. Transfer Admission

   a. A degree-seeking student who, after graduating from high school or earning a GED, has earned at least fourteen (14) or more semester hours of transferable academic college level credit from a regionally accredited college or university with a minimum cumulative GPA of 2.00 may be admitted.

b. A student not meeting the requirement in subsection 7.a. may petition the institutional admission director to be admitted. If admitted, the student must enroll on probation status, meet all conditions imposed by the institutional admissions committee, and complete the first semester with a minimum 2.00 GPA, or may be dismissed.

8. Career Technical Education Admissions

a. Admission Standards

Regular or Provisional admission standards apply to individuals who seek a technical certificate or Associate of Applied Science (A.A.S.) degree through a career technical program. The admission standards and placement criteria do not apply to workforce development or short-term training programs. Career technical programs employ program admission processes in addition to institutional program admission.

b. Placement Tests

Placement test scores indicating potential for success are generally required for enrollment in a career technical program of choice. Placement score requirements vary according to the program.

c. Idaho Technical College System

The career technical programs are offered at the following locations:

Region I	Coeur d'Alene, North Idaho College
Region II	Lewiston, Lewis-Clark State College
Region III	Nampa, College of Western Idaho
Region IV	Twin Falls, College of Southern Idaho
Region V	Pocatello, Idaho State University
Region VI	Idaho Falls, College of Eastern Idaho

d. Student Advising

i. Clarify the importance of career planning and preparation: high school students should be actively engaged in career planning prior to entering the 9th grade.

Career planning assures that students have sufficient information about self and work requirements to adequately design an education program to reach their career goals.

ii. Emphasize that career technical courses in high school, including career technical advanced opportunities and work-based learning connected to school-based learning, are beneficial to students seeking continued education in career technical programs at the postsecondary level.

iii. Clarify the kind of educational preparation necessary to successfully enter and complete postsecondary studies. Mathematics and science are essential for successful performance in many career technical programs. Programs of a technical nature generally require greater preparation in applied mathematics and laboratory sciences.

iv. Clarify that career technical programs of one or two years in length may require additional time if applicants lack sufficient educational preparation.

e. Career Technical Regular Admission

Students desiring Regular Admission to any of Idaho's technical colleges must meet the following standards. Students planning to enroll in programs of a technical nature are also strongly encouraged to complete the recommended courses. Admission to a specific career technical program is based on the capacity of the program and specific academic and/or physical requirements established by the technical college/program.

i. Standards for students who graduated from high school in 1997 or earlier

1) High School diploma with a minimum 2.0 GPA[1]; and

2) Placement examination[2] (ACT, SAT or other diagnostic/placement tests as determined by the institution. Scores may also be used to determine placement eligibility for specific career technical programs.); and

[1]An institution may substitute a composite index placement exam score and high school GPA for the GPA admission requirement.

[2]If accommodations are required to take the placement exam(s) because of a disability, please contact the College to which you are interested in applying.

3) Satisfactory completion of high school coursework that includes at least the following:

   a) Mathematics -- 4 credits (6 credits recommended) from challenging math sequences of increasing rigor selected from courses such as Algebra I, Geometry, Applied Math I, II, and III, Algebra II, Trigonometry, Discrete Math, Statistics, and other higher level math courses. Two (2) mathematics credits must be taken in the 11th or 12th grade. Less rigorous mathematics courses taken in grades 10-12 after 1998, such as pre-algebra, review mathematics, and remedial mathematics, shall not be counted.

   b) Science -- 4 credits (6 credits recommended, with 4 credits in laboratory science) including at least 2 credits of laboratory science from challenging science courses including applied biology/chemistry, principles of technology (applied physics), anatomy, biology, earth science, geology, physiology, physical science, zoology, physics, chemistry, and agricultural science and technology courses (500 level and above).

   c) Secondary Language Arts and Communication -- 8 credits. Applied English in the Workplace may be counted for English credit.

   d) Other -- Career technical courses, including postsecondary credits earned pursuant to Board Policy III.Y. Advanced Opportunities and organized work-based learning experiences connected to the school-based curriculum, are strongly recommended. High School Work Release time not connected to the school-based curriculum will not be considered.

ii. Standards for others Seeking Regular Admission

Individuals who graduated from high school, received their GED prior to 1997, or who are at least 21 years old and who desire Regular Admission to the technical colleges must have a:

1) High School diploma with a minimum 2.0 GPA; or

2) General Educational Development (GED) certificate[3]; and

3) ACT, SAT or other diagnostic/placement tests as determined by the institutions. Scores may also be used to determine admission eligibility for specific career technical programs.

9. Career Technical Provisional Admission

Students who do not meet all requirements for regular admission may apply to a technical program under provisional admission. Provisionally admitted students who are conditionally admitted must successfully complete appropriate remedial, general and/or technical education coursework related to the career technical program for which regular admission status is desired, and to demonstrate competence with respect to that program through methods and procedures established by the technical college. Students desiring Provisional Admission must have a:

a. High School diploma or GED certificate[3]; and
b. ACT, SAT or other diagnostic/placement tests as determined by the institutions. Scores may also be used to determine placement eligibility for specific career technical programs.)

10. Career Technical Placement Criteria: Procedures for placement into specific career technical programs

Specific career technical programs may require different levels of academic competency and admission requirements. Students must also be familiar with the demands of a particular occupation and how that occupation matches individual career interests and goals. Therefore, before students can enroll in a specific program, the following placement requirements must be satisfied:

a. Specific program requirements (including placement exam scores) established by the technical program. A student who does not meet the established requirements for the program of choice will have the opportunity to participate in remedial education to improve their skills; and

b. Formal procedures and definitions for program admission employed by the

[3]Certain institutions allow individuals who do not have a high school diploma or GED to be admitted if they can demonstrate the necessary ability to succeed in a technical program through appropriate tests or experiences determined by the institution.

technical college. Program admission requirements and procedures are clearly defined and published for each program.

SUBJECT

Board Policy III.Z, Waiver of Requirement to Update Three-Year Plans

REFERENCE

October 20, 2016	The Board approved the first reading of the proposed amendments to Board Policy III.Z that updates institutions' statewide program responsibilities.
December 15, 2016	The Board approved the second reading of proposed amendments to Board Policy III.Z. that updates institutions' statewide program responsibilities.
December 21, 2017	The Board approved the first reading of proposed amendments to Board Policy III.Z that changes the planning timeframe from five years to three years.
February 15, 2018	The Board approved the second reading of proposed amendments to Board Policy III.Z.
June 21, 2018	The Board approved the first reading of proposed amendments to Board Policy III.Z. Add responsibilities for applied baccalaureate degrees to each region.
August 16, 2018	The Board approved the second reading of proposed amendments to Board Policy III.Z.

APPLICABLE STATUTE, RULE, OR POLICY

Idaho State Board of Education Governing Policies and Procedures, Section III.Z, Planning and Delivery of Postsecondary Programs and Courses.
Section 33-113, Idaho Code, Limits of Instruction.
Section 33-2107A, Idaho Code.

BACKGROUND/DISCUSSION

The purpose of Board Policy III.Z. is to ensure all of Idaho's public postsecondary institutions meet the educational and workforce needs of the state through program planning, alignment, collaboration and coordination, and to meet the statutory requirement to "as far as practicable prevent wasteful duplication of effort" by the institutions.

Board Policy III.Z. outlines the process and procedures for planning and delivery of Statewide and Regional Programs. As part of this process, institutions are required to submit to the Board office plans for the proposed delivery of Statewide and Regional Programs over a three-year period. The three-year plan is updated and approved by the Board annually at its August Board meeting. This is accomplished according to a schedule developed by Board staff. Updated plans were in progress and scheduled for submission in March of 2020. In light of the COVID-19 pandemic and recent impacts to institution budgets and state funding, institutions have identified a need to reevaluate program plans to align with budget realities. To meet a request for flexibility by the institutions during this unprecedented time, Board approval is requested to waive the requirement that three year plans be reviewed and approved at the August Board meeting this year, as provided in Board Policy III.Z.

IMPACT

Approval of the waiver will provide institutions the additional time necessary to reevaluate projected programs and make adjustments based on current funding and needs.

ATTACHMENTS

Attachment 1 – Board Policy III.Z., Planning and Delivery of Postsecondary Programs and Courses

STAFF COMMENTS AND RECOMMENDATIONS

The three-year plan is intended to serve as the foundation for advising and informing the Board in their efforts to coordinate educational programs throughout the state. This waiver will postpone the requirement for institutions to update their plans in 2020 with proposed new programs. The updated plan would have added projections for the 2024-25 academic year and updated plans for the 2022-23 and 2023-24 academic years. If the Board approves the waiver, the current three-year plans approved by the Board at their August 2019 meeting will remain in effect and provide projected programs for the 2020-21 academic year at each institution. The Council on Academic Affairs and Programs intends to continue discussion regarding program planning, in particular for the statewide cybersecurity initiative, with the goal of resuming three-year planning for the next academic year. Even with this waiver in place, institutions will continue active program planning and adaptation in their response to the pandemic.

Additionally, staff notes that a work group of the Council on Academic Affairs and Programs is evaluating Board Policy III.Z. holistically as a directive from the Presidents Leadership Council, to determine if amendments or clarification are necessary to promote and encourage collaboration of programs among institutions. Potential amendments may generate modifications to the foundation of program planning moving forward.

The proposed temporary waiver was discussed with the Council on Academic Affairs and Programs on May 14, 2020; and with the Instruction, Research and Student Affairs Committee on May 28, 2020.

Staff recommends approval.

BOARD ACTION

I move to waive the requirement in Board Policy III.Z.2.a.i. that the three year plan be reviewed and approved by the Board at the August 2020 Board meeting.

Moved by __________ Seconded by __________ Carried Yes _____ No _____

ATTACHMENT 1

Idaho State Board of Education

GOVERNING POLICIES AND PROCEDURES

SECTION: III. POSTSECONDARY AFFAIRS

Subsection: Z. Planning and Delivery of Postsecondary Programs and Courses

August 2018

The purpose of this policy is to ensure Idaho's public postsecondary institutions meet the educational and workforce needs of the state through academic planning, alignment of programs and courses (hereinafter referred to collectively as "programs"), and collaboration and coordination. This subsection shall apply to the University of Idaho, Boise State University, Idaho State University, Lewis-Clark State College, College of Eastern Idaho, College of Southern Idaho, College of Western Idaho, and North Idaho College (hereinafter "institutions"). The State Board of Education (the Board) aims to optimize the delivery of academic programs while allowing institutions to grow and develop consistent with their vision and mission with an appropriate alignment of strengths and sharing of resources.

This policy requires the preparation and submission of academic plans to advise and inform the Board in its planning and coordination of educational programs in a manner that enhances access to quality programs, while concurrently increasing efficiency, avoiding unnecessary duplication and maximizing the cost-effective use of educational resources. As part of this process, the Board hereby identifies and reinforces the responsibilities of the institutions governed by the Board to deliver Statewide Programs. The provisions set forth herein serve as fundamental principles underlying the planning and delivery of programs pursuant to each institution's assigned Statewide and Service Region Program Responsibilities. These provisions also require collaborative and cooperative agreements, or memorandums of understanding, between and among the institutions.

This policy is applicable to campus-based face-to-face programs, including those that use technology to facilitate and/or supplement a physical classroom experience. It also applies to hybrid and blended programs where a substantial portion of the content is delivered on-line and typically has reduced seat time.

1. Definitions

    a. Designated Institution shall mean an institution whose main campus is located in a service region as identified in subsection 2.b.ii.1) and 2) below.

        i. For purposes of this policy, with respect to academic programs, Designated Institutions and Partnering Institutions shall have Service Region Program Responsibility for those regions identified in subsection 2.b.ii.1).

        ii. For purposes of this policy, with respect to career technical programs, Designated Institutions and Partnering Institutions shall include only the College of Southern Idaho, College of Western Idaho, North Idaho College, College of Eastern Idaho, Lewis-Clark State College, and Idaho State University and shall have Service Region Program Responsibility for those regions identified in subsection 2.b.ii.2).

b. A memorandum of understanding (MOU) is an agreement between two or more institutions offering programs within the same service region that details how such programs will be delivered in a collaborative manner. An MOU is intended to provide specific, practical details that build upon what has been provided in each Institution's Plan.

c. Partnering Institution shall mean either (i) an institution whose main campus is located outside of a Designated Institution's identified service region but which, pursuant to a Memorandum of Understanding, offers Regional Programs in the Designated Institution's primary service region, or (ii) an institution not assigned a Statewide Program Responsibility which, pursuant to a Memorandum of Understanding with the institution assigned the Statewide Program Responsibility, offers and delivers a statewide educational program.

d. Service Region Program shall mean an educational program identified by the Board to be delivered by a Designated Institution within its respective service region that meets regional educational and workforce needs.

e. Service Region Program Responsibility shall mean an institution's responsibility to offer and deliver a Service Region Program to meet regional educational and workforce needs in its primary service region as defined in subsection 2.b.ii.1) and 2) below. Service Region Program Responsibilities are assigned to the Designated Institution in each service region, but may be offered and delivered by Partnering Institutions in accordance with the procedures outlined in this policy.

f. Statewide Program shall mean an educational program identified by the Board to be delivered by a particular institution which meets statewide educational and workforce needs. Lewis-Clark State College, College of Eastern Idaho, North Idaho College, College of Southern Idaho, and College of Western Idaho do not have Statewide Program Responsibilities.

g. Statewide Program Responsibility shall mean an institution's responsibility to offer and deliver a Statewide Program in all regions of the state. Statewide Program Responsibilities are assigned to a specific institution by the Board, taking into account the degree to which such program is uniquely provided by the institution.

2. Planning and Delivery Process and Requirements

   a. Planning

      i. Three-Year Plan

         The Board staff shall, using the Institution Plans submitted, create and maintain a rolling three (3) year academic plan (Three-Year Plan) which includes all current and proposed institution programs. The Three-Year Plan shall be approved by the Board annually at its August Board meeting.

ii. Institution Plan

Each institution shall, in accordance with a template to be developed by the Board's Chief Academic Officer, create and submit to Board staff a rolling three (3) year academic plan, to be updated annually, that describes all current and proposed programs and services to be offered in alignment with each institution's Statewide and Service Region Program Responsibilities (the Institution Plan). Institution Plans shall be developed pursuant to a process of collaboration and communication with the other institutions in the state.

1) Statewide Programs

Institutions assigned a Statewide Program Responsibility shall plan for and determine the best means to deliver such program. Each institution assigned a Statewide Program Responsibility shall include in its Institution Plan all currently offered and proposed programs necessary to respond to the workforce and educational needs of the state relating to such Statewide Program Responsibilities. Each Institution Plan shall include the following information for proposed Statewide programs:

a) A description of the Statewide Programs to be delivered throughout the state and the anticipated resources to be employed.

b) A description of the Statewide Programs to be offered by a Designated or Partnering Institution.

c) A summary of the Memoranda of Understanding (MOU's), if any, to be entered into with Partnering Institutions pursuant to Subsection 2.b.iii. below.

2) Service Region Programs

It is the responsibility of the Designated Institution to plan for and determine the best means to deliver Service Region Programs that respond to the educational and workforce needs of its service region. If, in the course of developing or updating its Institution Plan, the Designated Institution identifies a need for the delivery of a program within its service region, and the Designated Institution is unable to provide the program, then the Designated Institution shall coordinate with a Partnering Institution (including institutions with Statewide Program Responsibilities if applicable) located outside of the service region to deliver the program in the service region.

The Institution Plan developed by a Designated Institution shall include the following:

a) A description of the proposed academic programs to be delivered in the service region, or outside of the service region, by the Designated Institution and the anticipated resources to be employed.

b) A description of proposed programs to be offered in the service region by Partnering Institutions, including any anticipated transition of programs to the Designated Institution.

c) A description of proposed Statewide Programs to be offered in the service region by an institution with Statewide Program Responsibilities, or by the Designated Institution in coordination with the institution holding the Statewide Program Responsibility.

d) A summary of proposed MOU's, if any, to be entered into between the Designated Institution and any Partnering Institutions in accordance with Subsection 2.b.iii. below.

3) Institution Plan Updates

Institution Plans shall be updated and submitted to Board staff annually as follows:

a) Preliminary Institution Plans shall be developed according to a template provided by the Board's Chief Academic Officer and submitted to the Council for Academic Affairs and Programs (CAAP) for review, discussion and coordination annually in April.

b) Following review by CAAP, Institution Plans shall be submitted to Board staff. Upon submission of the Institution Plans to Board staff, the Board's Chief Academic Officer shall review the Institution Plans for the purpose of optimizing collaboration and coordination among institutions, ensuring efficient use of resources, and avoiding unnecessary duplication of programs.

c) In the event the Board's Chief Academic Officer recommends material changes, he/she shall work with the institutions and then submit those recommendations to CAAP for discussion prior to submission to the Board for inclusion in the Three-Year Plan.

d) The Board's Chief Academic Officer shall then provide their recommendations to the Board for enhancements, if any, to the Institution Plans at a subsequent Board meeting. The Board shall approve the Institution Plans annually through the Three-Year Plan submitted by Board staff. Board approval of Institution Plans acts as a roadmap for institutional planning and does not constitute Board approval of a program. Institutions are still required to follow the standard program approval process as identified in Board Policy Section III.G to gain program approval.

b. Delivery of Programs

i. Statewide Program Delivery
The Board has established statewide program responsibilities for the following institutions. This statewide program list shall be updated by the Board every two years.

Boise State University must assess the need for and, when determined necessary by the assessment, ensure the statewide delivery of all educational programs in the following degree program areas:

Program Name	Degrees
Public Policy and Administration	M.S., Ph.D.
Community and Regional Planning	M.C.R.P., Ph.D.
Social Work (Region V-VI —shared with ISU)	M.S.W.
Social Work	Ph.D.

Idaho State University must assess the need for and, when determined necessary by the assessment, ensure the statewide delivery of all educational programs in the following degree program areas:

Program Name	Degrees
Audiology	Au.D., Ph.D.
Physical Therapy	D.P.T., Ph.D.
Occupational Therapy	M.O.T.
Pharmaceutical Science	M.S., Ph.D.
Pharmacy Practice	Pharm.D.
Nursing (Region III shared w/ BSU)	M.S., D.N.P.
Nursing	Ph.D.
Physician Assistant	M.P.A.S.
Speech Pathology	M.S.

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Program Name	Degrees
Deaf Education	M.S.
Sign Language Interpreting	B.S.
Health Education	M.H.E.
Public Health	M.P.H.
Health Physics	B.S., M.S., Ph.D.
Dental Hygiene	B.S., M.S.
Medical Lab Science	B.S., M.S.
Clinical Psychology	Ph.D.

University of Idaho must assess the need for and, when determined necessary by the assessment, ensure the statewide delivery of all educational programs in the following degree program areas:

Program Name	Degrees
Law	J.D.
Architecture	B.S. Arch., M. Arch.
Integrated Architecture & Design	M.S.
Landscape Architecture	B.S.L.A., M.L.A.
Interior Design	B.I.D., M.S.
Animal & Veterinary Science	B.S.A.V.S.
Animal Science	M.S.
Veterinary Science	D.V.M.
Plant Science	M.S., Ph.D.
Agricultural Economics	B.S.Ag.Econ.
Applied Economics (Agricultural)	M.S.
Food Science	B.S.F.S., M.S., Ph.D.
Forestry	B.S.Forestry
Renewable Materials	B.S.Renew.Mat.
Wildlife Resources	B.S.Wildl.Res.
Fishery Resources	B.S.Fish.Res.
Natural Resource Conservation	B.S.Nat.Resc.Consv.
Rangeland Ecology & Management	B.S.Rangeland.Ecol.Mgmt.
Fire Ecology & Management	B.S.Fire.Ecol.Mgt.
Natural Resource concentrations in: • Forestry • Renewable Materials • Wildlife Resources • Fishery Resources • Natural Resource Conservation • Rangeland Ecology & Management • Fire Ecology & Management	M.S., M.N.R., Ph.D.

ii. Service Region Program Delivery

The Board has established service regions for the institutions based on the six geographic areas identified in Section 33-2101, Idaho Code. A Designated Institution shall have the Service Region Program Responsibility to assess and ensure the delivery of all educational programs and services necessary to meet the educational and workforce needs within its assigned service region.

1) Academic Service Regions

Region I shall include the area within Area No.1 under Section 33-2101, Idaho Code. Lewis-Clark State College, the University of Idaho, and North Idaho College are the Designated Institutions serving undergraduate needs. The University of Idaho is the Designated Institution serving the graduate education needs. Lewis-Clark State College, and North Idaho College are the Designated Institutions serving applied baccalaureate degree needs.

Region II shall include the area within Area No.2 under Section 33-2101, Idaho Code. Lewis-Clark State College and the University of Idaho are the Designated Institutions serving undergraduate needs. The University of Idaho is the Designated Institution serving the graduate education needs.

Region III shall include the area within Area No.3 under Section 33-2101, Idaho Code. Boise State University and College of Western Idaho are the Designated Institutions serving undergraduate needs. Boise State University is the Designated Institution serving graduate education needs. Boise State University and College of Western Idaho are the Designated Institutions serving applied baccalaureate degree needs.

Region IV shall include the area within Area No.4 under Section 33-2101, Idaho Code. Idaho State University and College of Southern Idaho are the Designated Institutions serving undergraduate needs. Idaho State University is the Designated Institution serving the graduate education needs, with the exception that Boise State University will meet undergraduate and graduate business program needs. Idaho State University and College of Southern Idaho are the Designated Institutions serving applied baccalaureate degree needs.

Region V shall include the area within Area No.5 under Section 33-2101, Idaho Code. Idaho State University is the Designated Institution serving undergraduate and graduate education needs.

Region VI shall include the area within Area No.6 under Section 33-2101, Idaho Code. Idaho State University and College of Eastern Idaho are the Designated Institutions serving undergraduate education needs. Idaho State University is the Designated Institution serving the graduate education needs. Idaho State University and College of Eastern Idaho are the Designated Institutions serving applied baccalaureate degree needs.

2) Career Technical Service Regions

Postsecondary career technical education is delivered by six (6) institutions, each having responsibility for serving one of the six geographic areas identified in Section 33-2101.

Region I shall include the area within Area No.1 under Section 33-2101, Idaho Code. North Idaho College is the Designated Institution.

Region II shall include the area within Area No.2 under Section 33-2101, Idaho Code. Lewis-Clark State College is the Designated Institution.

Region III shall include the area within Area No.3 under Section 33-2101, Idaho Code. College of Western Idaho is the Designated Institution

Region IV shall include the area within Area No.4 under Section 33-2101, Idaho Code. College of Southern Idaho is the Designated Institution.

Region V shall include the area within Area No.5 under Section 33-2101, Idaho Code. Idaho State University is the Designated Institution.

Region VI shall include the area within Area No.6 under Section 33-2101, Idaho Code. College of Eastern Idaho is the Designated Institution.

3) Program Offerings by Partnering Institutions

If a Partnering Institution (other than an institution with Statewide Program Responsibilities) identifies a Service Region Program not identified, or anticipated to be identified, in a Designated Institution's Plan, and the Partnering Institution wishes to offer such program in the Designated Institution's service region, then the Partnering Institution may communicate with the Designated Institution for the purpose of allowing the Partnering Institution to deliver such program in the service region and to include the program in the Designated Institution's Plan. In order to include the program in the Designated Institution's Plan, the Partnering Institution must demonstrate the need within the service region for delivery of the program, as determined by the Board (or by the Administrator of the Division of Career Technical Education in the case of career technical level programs). In order to demonstrate the need for the delivery of a program in a service region, the Partnering Institution shall complete and submit to the Chief Academic Officer of the Designated Institution, to CAAP and to Board staff, in accordance with a schedule to be developed by the Board's Chief Academic Officer, the following:

a) A study of business and workforce trends in the service region indicating anticipated, ongoing demand for the educational program to be provided.

b) A survey of potential students evidencing demand by prospective students and attendance sufficient to justify the short-term and long-term costs of delivery of such program.

c) A complete description of the program requested to be delivered, including a plan for the delivery of the program, a timeline for delivery of the program, the anticipated costs of delivery, the resources and support required for delivery (including facilities needs and costs), and program syllabuses.

4) Designated Institution's First Right to Offer a Program

In the event the Partnering Institution has submitted the information set forth above to the Board's Chief Academic Officer) for inclusion in the Designated Institution's Plan, and a need is demonstrated by the Partnering Institution for such program in the service region, as determined by the Board (or by the Administrator for the Division of Career Technical Education in the case of career technical level programs), or prior to the submission of an updated Institution Plan by the Designated Institution, it is determined by the Board that an emergency need has arisen for such program in the service region the Designated Institution shall have a first right to offer such program.

The Designated Institution must within six (6) months (three (3) months in the case of associate level or career technical level programs) of receiving the request from a Partnering Institution to offer said program determine whether it will deliver such program on substantially the same terms (with respect to content and timing) described by the Partnering Institution. In the event the Designated Institution determines not to offer the program, the Partnering Institution may offer the program according to the terms stated, pursuant to an MOU to be entered into with the Designated Institution. If the Partnering Institution materially changes the terms and manner in which the program is to be delivered, the Partnering Institution shall provide written notice to the Chief Academic Officer of the Designated Institution and to the Board's Chief Academic Officer of such changes and the Designated Institution shall be afforded the opportunity again to review the terms of delivery and determine within three (3) months of the date of notice whether it will deliver such program on substantially the same terms.

iii. Memoranda of Understanding

When a service region is served by more than one institution for the delivery of an academic or technical credential defined in Board Policy Section III.E., an MOU shall be developed between such institutions as provided herein and submitted to the Board's Chief Academic Officer for review and approval by the Board prior to entering into such agreements. Each MOU shall be entered into based on the following guidelines, unless otherwise approved by the Board.

If an institution with Statewide Program Responsibility has submitted the information set forth in Subsection 2.a.ii. above to a Designated Institution and Board staff in a timely manner (as determined by the Board's Chief Academic Officer) for inclusion in the Designated Institution's Plan, then the Designated Institution shall identify the program in its Institution Plan and enter into an MOU with the institution with Statewide Program Responsibility in accordance with this policy. If, prior to the submission of an updated Institution Plan by the Designated Institution, it is determined by the Board that an emergency need has arisen for such program in the service region, then upon Board approval the institution with Statewide Program Responsibility and the Designated Institution shall enter into an MOU for the delivery of such program in accordance with the provisions of this policy.

iv. Facilities

For programs offered by a Partnering Institution (whether an institution with Statewide Program Responsibilities, or otherwise) within a municipal or metropolitan area that encompasses the campus of a Designated Institution, the Partnering Institution's programs offerings shall be conducted in facilities located on the campus of the Designated Institution to the extent the Designated Institution is able to provide adequate and appropriate property or facilities (taking into account financial resources and programmatic considerations), or in facilities immediately adjacent to the campus of the Designated Institution. Renting or building additional facilities shall be allowed only upon Board approval, based on the following:

1) The educational and workforce needs of the local community demand a

separate facility at a location other than the campus of the Designated Institution or adjacent thereto as demonstrated in a manner similar to that set forth in Subsection 2.b.ii.1) above, and

2) The use or development of such facilities are not inconsistent with the Designated Institution's Plan.

Facilities rented or built by a Partnering Institution (whether an institution with Statewide Program Responsibilities, or otherwise) on, or immediately adjacent to, the "main" campus of a Designated Institution may be identified (by name) as a facility of the Partnering Institution, or, if the facility is rented or built jointly by such institutions, as the joint facility of the Partnering Institution and the Designated Institution. Otherwise, facilities utilized and programs offered by one or more Partnering Institutions within a service region shall be designated as "University Place at (name of municipality)."

For programs offered by a Partnering Institution (whether an institution with Statewide Program Responsibilities, or otherwise) within a municipality or metropolitan area encompassing a campus of a Designated Institution, to the extent programmatically possible, auxiliary services (including, but not limited to, bookstore, conference and other auxiliary enterprise services) and student services (including, but not limited to, library, information technology, and other auxiliary student services) shall be provided by the Designated Institution. To the extent programmatically appropriate, registration services shall also be provided by the Designated Institution. It is the goal of the Board that a uniform system of registration ultimately be developed for all institutions governed by the Board. The Designated Institution shall offer these services to students who are enrolled in programs offered by the Partnering Institution in the same manner, or at an increased level of service, where appropriate, as such services are offered to the Designated Institution's students. An MOU between the Designated Institution and the Partnering Institution shall outline how costs for these services will be allocated.

v. Duplication of Courses

If courses necessary to complete a Statewide Program are offered by the Designated Institution, they shall be used and articulated into the Statewide Program.

vi. Program Transitions

Institutions with Statewide Program or Service Region Program Responsibilities may plan and develop the capacity to offer a program within a service region where such program is currently being offered by another institution (the Withdrawing Institution) as follows:

1) The institution shall identify its intent to develop the program in the next update of its Institution Plan. The institution shall demonstrate its ability to offer the program through the requirements set forth in Subsection 2.b.ii.3) above.

2) Except as otherwise agreed between the institutions pursuant to an MOU, the Withdrawing Institution shall be provided a minimum three (3) year transition period to withdraw its program. If the Withdrawing Institution wishes to withdraw its program prior to the end of the three (3) year transition period, it may do so but in no event earlier than two (2) years from the date of notice (unless otherwise agreed). The Withdrawing Institution shall enter into a transition MOU with the institution that will be taking over delivery of the program that includes an admissions plan between the institutions providing for continuity in student enrollment during the transition period.

vii. Discontinuance of Programs

Unless otherwise agreed between the applicable institutions pursuant to an MOU, if, for any reason, (i) a Designated Institution offering programs in its service region that supports a Statewide Program of another institution, (ii) a Partnering Institution offering programs in the service region of a Designated Institution, or (iii) an institution holding a Statewide Program Responsibility offering Statewide Programs in the service region of a Designated Institution, wishes to discontinue offering such program(s), it shall use its best efforts to provide the institution with Statewide or Service Region Program Responsibility, as appropriate, at least one (1) year's written notice of withdrawal, and shall also submit the same written notice to the Board and to oversight and advisory councils. In such case, the institution with Statewide or Service Region Program Responsibilities shall carefully evaluate the workforce need associated with such program and determine whether it is appropriate to provide such program. In no event will the institution responsible for the delivery of a Statewide or Service Region Program be required to offer such program (except as otherwise provided herein above).

3. Existing Programs

Programs being offered by a Partnering Institution (whether an institution with Statewide Program Responsibilities, or otherwise) in a service region prior to July 1, 2003, may continue to be offered pursuant to an MOU between the Designated

Institution and the Partnering Institution, subject to the transition and notice periods and requirements set forth above.

4. Oversight and Advisory Councils

   The Board acknowledges and supports the role of oversight and advisory councils to assist in coordinating, on an ongoing basis, the operational aspects of delivering programs among multiple institutions in a service region, including necessary resources and support and facility services, and the role of such councils in interacting and coordinating with local and regional advisory committees to address and communicate educational needs indicated by such committees. Such interactions and coordination, however, are subject to the terms of the MOU's entered into between the institutions and the policies set forth herein.

5. Resolutions

   All disputes relating to items addressed in this policy shall be forwarded to the Board's Chief Academic Officer for review. The Board's Chief Academic Officer shall prescribe the method for resolution. The Board's Chief Academic Officer may forward disputes to CAAP and if necessary make recommendation regarding resolution to the Board. The Board will serve as the final arbiter of all disputes.

6. Exceptions

   a. This policy is not applicable to programs for which 90% or more of all activity is required or completed online, or dual credit courses for secondary education.

   b. This policy also does not apply to courses and programs specifically contracted to be offered to a private, corporate entity. However, in the event that an institution plans to contract with a private corporate entity (other than private entities in the business of providing educational programs and course) outside of their Service Region, the contracting institution shall notify the Designated Institutions in the Service Region and institutions with Statewide Program Responsibilities, as appropriate. If the corporate entity is located in a municipality that encompasses the campus of a Designated Institution, the Board encourages the contracting institution to include and draw upon the resources of the Designated Institution insomuch as is possible.

SUBJECT

Higher Education Research Council Annual Update

REFERENCE

February 2015	The Board approved changes to the Higher Education Research Strategic Plan
October 2015	The Board was provided the Performance Measure Report for the Higher Education Research Strategic Plan
December 2016	The Board approved changes to the Higher Education Research Strategic Plan
February 2017	The Board was provided the annual update of the Higher Education Research Council
February 2018	The Board was provided the annual update of the Higher Education Research Council
June 2019	The Board was provided the annual update of the Higher Education Research Council

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.

The Statewide Strategic Plan for Research assists in the identification of research areas that will enhance the economy of Idaho through the collaboration of academia, industry, and government and ensures efforts are in alignment with identified areas of strength at our public universities. The most recent changes to the strategic plan were approved by the Board in December 2016.

The plan represents the role Idaho's research universities play in driving innovation, economic development, and enhancing the quality of educational programs in strategic areas. The plan identifies areas of strength among Idaho's research universities, research challenges and barriers facing the universities, research opportunities Idaho should capitalize upon to further build its research base, goals to build the research pipeline through engaging undergraduate students, and steps for achieving the research vision for Idaho's universities. Additional responsibilities of HERC include the management of 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). 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 those that are designed to develop spin-off companies. 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 between the three Idaho public research institutions (Boise State University, Idaho State University, University of Idaho), the Idaho National Laboratory, and the University of Wyoming.

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 input to the Higher Education Research Council on areas of focus and strategic direction.

ATTACHMENTS

Attachment 1 – Statewide Strategic Plan for Higher Education Research
Attachment 2 – FY19 Performance Measure Report
Attachment 3 – FY19 Research Activity Report
Attachment 4 – FY19 Infrastructure Summary Report
Attachment 5 – FY19 Undergraduate Research Report
Attachment 6 – FY19 Idaho Conference on Undergraduate Research
Attachment 7 – HERC FY20 Budget Allocation
Attachment 8 – FY20 IGEM Fund Summaries
Attachment 9 – FY20 Incubation Fund Summaries
Attachment 10 – 2019 CAES Annual Report
Attachment 11 – Draft presentation to the Board

STAFF COMMENTS AND RECOMMENDATIONS

In addition to the responsibility for recommendations to the Board on the Board's Higher Education Research Strategic plan (Attachment 1), HERC is responsible for distributing approximately $4.2M in funds used for the mission of HERC and to incentivize industry and institution research partnerships. Attachment 2 is the Fiscal Year 2019 performance measure report. Attachment 3 is a compilation of the research institutions' annual research activity reports. Attachment 4 summarizes the infrastructure funding in FY19. Attachment 5 contains the institutions' reports on undergraduate research. Attachment 6 is the report on the Idaho Conference on Undergraduate Research. Attachment 7 outlines HERC's FY20 budget allocation. Attachment 8 are summaries of the IGEM projects funded by HERC in FY20. Attachment 9 are summaries of the Incubation Fund projects. Attachment 10 is the annual report for CAES. Attachment 11 is a draft slide deck presentation to the Board, highlighting the foregoing information and recent research activities supported by HERC at the institutions.

The strategic plan is monitored annually and updated as needed based on the work of HERC and direction from the Board. HERC uses a competitive process for distributing funds from the Incubation Fund category and the HERC IGEM Fund category. All proposals that are considered must be in alignment with the Board's Higher Education Research Strategic Plan.

BOARD ACTION

This item is for informational purposes only.

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HIGHER EDUCATION RESEARCH STRATEGIC PLAN

(2017-2022)

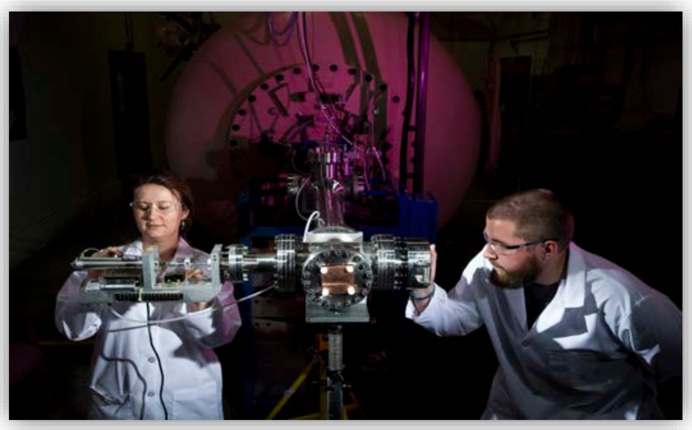
Submitted by: Higher Education Research Council

State Board of Education Approved December 2016

EXECUTIVE SUMMARY

Research is being increasingly acknowledged by industry, government and education as a key factor in the future economic vitality of Idaho. The universities and colleges of Idaho's system of higher education understand the need for greater collaboration in order to be competitive in today's global environment. Recognizing the need to focus on and emphasize existing strengths and opportunities in Idaho's research community, the vice presidents for research and economic development developed the following statewide strategic plan for research to ensure the greatest potential for achieving a vital and sustainable research base for Idaho. The strategic plan identifies the key research areas (basic, translational and clinical) that will become the focal points for research and economic development through partnering among academia, industry and government in science, technology, and creative activity.

Research is fundamental to the mission of a university due to its role in knowledge discovery and in providing new ideas for technology commercialization via patents, copyright, licenses and startup companies. University faculty who engage in research and creative activity are at the leading edge of their respective fields. Research also enhances the national reputation of the faculty and the universities. These faculty and their vibrant research programs attract the best graduate and undergraduate students by providing unique cutting-edge learning experiences in their research laboratories, studios, field sites and classrooms. On the most basic level, and also bolstered through collaborative, interdisciplinary and interprofessional research, such activities strengthen a university's primary product — innovative, well-educated students ready to enter a competitive workforce.



Research is the foundation of a university's economic development role. The influx of research dollars from external grants and contracts creates new jobs at the university, along with the attendant purchases of supplies, services, materials and equipment. The results of the research are new knowledge, new ideas, and new processes, which lead to patents, startup companies, more efficient businesses as well as a highly trained workforce prepared to tackle 21st century challenges.

Idaho's research universities have strengths and opportunities for economic development in 1) Energy Systems, 2) Natural Resource Utilization and Conservation, 3) Biomedical and Healthcare Sciences, 4) Novel Materials and 5) Systems Engineering and Cybersecurity.

By focusing collaborative efforts in these areas, the research universities will expand research success by:

- Helping Idaho institutions focus on their research strengths;
- Strengthening collaboration among Idaho institutions;
- Creating research and development opportunities that build relationships between universities and the private sector;
- Contributing to the economic development of the State of Idaho;
- Enhancing learning and professional development through research and scholarly activity – also by promoting interdisciplinary and inter-professional research; and
- Building and improving the research infrastructure of Idaho universities to meet current and future research needs.

This statewide Strategic Research Plan for Idaho Higher Education is a tool for identifying and attaining quantifiable goals for research and economic growth and success in Idaho. The plan will be reviewed and updated annually as needed amid the fast-changing pace of research discovery.

VISION

Idaho's public universities will be a catalyst and engine to spur creation of new knowledge, technologies, products and industries that lead to advances and opportunities for economic growth and enhance the quality of life in Idaho and the nation.

MISSION

The research mission for Idaho's universities is to develop a sustainable resource base by:

- Identifying, recruiting and retaining top faculty with expertise in key research areas;
- Building research infrastructure including facilities, instrumentation, connectivity and database systems to support an expanding statewide and national research platform;
- Attracting top-tier students to Idaho universities at the undergraduate and graduate levels and providing outstanding education and research opportunities that will prepare them to excel in future careers;
- Raising awareness among state, national and international constituencies about the research excellence and capabilities of Idaho's universities by developing and implementing targeted outreach, programs and policies; and
- Collaborating with external public, private, state and national entities to further the shared research agenda for the state, thereby promoting economic and workforce development and addressing the needs and challenges of the state, region and nation.

GOALS AND OBJECTIVES

Goal 1: Increase 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 1.A.1: Statewide amount of total annual research and development expenditures as reported in the National Science Foundation (NSF) Higher Education Research and Development Survey.
Benchmark: 10% increase per year.

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

Performance Measure 1.B.1: 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.
Benchmark: 10% increase per year.

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

Performance Measure 1.C.1: 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).
Benchmark: 50% increase per year.

Performance Measure 1.C.2: 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). Benchmark: 30% increase per year.

Performance Measure 1.C.3: 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.
Benchmark: 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 2.A.1: Number of new sponsored projects involving the private sector.
Benchmark: 50% increase per year.

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 3.A.1: Number of technology transfer agreements (as defined by AUTM [Association of University Technology Managers]).
Benchmark: 15% increase per year.

Performance Measure 3.A.2: Number of invention disclosures (including biomic varieties).
Benchmark: 1 for every $2M of research expenditures.

Performance Measure: 3.A.3: Amount of licensing revenues.
Benchmark: 10% increase per year.

Performance Measure: 3.A.4: Number of startup companies.
Benchmark: 10% increase per year.

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 4.A.1: Number of undergraduate and graduate students paid from sponsored projects.
Benchmark: 20% increase per year.

Performance Measure 4.A.2: Percentage of baccalaureate students who had a research experience.
Benchmark: 20% increase per year.

Performance Measure 4.A.3: Number of faculty and staff paid from sponsored projects.
Benchmark: 20% increase per year.

RESEARCH OPPORTUNITIES

Idaho's research universities have developed statewide strengths in strategic research areas that have great potential to drive future economic growth and success. The criteria used to select these areas include: number of faculty and qualifications; peer-reviewed publications and impact; infrastructure (facilities, equipment, information technology, staff); external grant and contract funding; academic programs; student involvement; potential benefit to the State of Idaho; and technology transfer activity, including patents, licenses, and startup companies. By focusing collective research efforts and resources in these areas, the universities will be on the most efficient and effective route to research success and state-wide economic development. These high impact areas include 1) Energy Systems, 2) Natural Resource Utilization and Conservation, 3) Biomedical and Healthcare Sciences, 4) Novel Materials, and 5) Systems Engineering and Cybersecurity.

Energy Systems: Energy is a critical driver of any economy. The projected increases in the population of the world and increases in the standard of living will produce severe strains on the ability to meet the demands of the next few decades. In addition, finite reserves of fossil fuels and pollution from their combustion requires that alternative sources of energy production be developed. The combination of natural resources in Idaho and presence of the Idaho National Laboratory makes energy a natural area of emphasis. Indeed, the three universities with research capabilities already have extensive research projects in this area. The Center for Advanced Energy Studies (CAES) is an example of the significant investment the three Idaho universities, the University of Wyoming, and the Idaho National Laboratory have made to develop expertise in nuclear science and engineering, materials science and engineering, energy systems design and analysis, fossil carbon conversion, geological systems and applications, energy policy and cybersecurity, and environmental and resource sustainability. Further growth in these areas not only takes advantage of the strong base but strongly supports a positive economic impact through new markets for new product development

Natural Resource Utilization and Conservation: In the broad field of natural resource utilization and conservation, Idaho's universities have expertise in water resources, wildfire management and restoration, agriculture, forestry, recreation, and geophysics and geochemical detection, geographical information systems, and monitoring of groundwater pollutants. For example, university geologists, ecologists, and policy experts are collaborating on broad-ranging research projects that examine and predict the impact of climate change on Idaho's water resources. As water is essential to agriculture, recreation, the ecosystem, and human health, the universities have research strength in an area of tremendous societal and economic impact. Agriculture remains an important part of the economy of Idaho. Development of new biomic varieties with improved resistance to disease and climate change remain an area of importance as does the development of new feeds for domestic fish production. The often competing demands for preservation and exploitation put on the environment require understanding of the various ecosystems in the state and region as well as societal, human health, and economic impacts of policy decisions. Recent national research imperatives, as particularly captured in National Science Foundation's Innovation at the Nexus of Food, Energy, and Water Systems (INFEWS) foundation-wide program and the Department of Energy's report Water-Energy Nexus: Challenges and Opportunities increasingly require multi-sectoral, multi-disciplinary approaches to problems in natural resource utilization and conservation. The depth and breadth of relevant research expertise in the biophysical, rural health and social science fields within Idaho's universities underscores an opportunity that a national emphasis on food, energy, and water security provides. Provided that enhanced coordination and collaboration between Idaho's universities can be successfully executed, we are particularly well-placed to exhibit national and international leadership at the nexus of food, energy, water system research. The future economic success of the state will rely on a deep understanding of these processes.

Biomedical and Healthcare Sciences: Idaho's universities have well-established research programs in selected areas of biological and biomedical sciences. University microbiologists and informatics experts, for example, study real-time change in pathogenic microorganisms that enable them to become resistant to drugs and chemical toxins thus resulting in worsening human disease and mortality rates. These effects are not restricted to humans, domestic and wild animals as well as food plants and trees are experiencing the same phenomena. Also, weeds are becoming resistant to herbicides. These phenomena are having a significant negative impact on Idaho's agriculture and forests. Further stress is being put on these important commercial sectors through climate variability. Research in these areas is critical for preserving important economic sectors of Idaho's economy while addressing future global needs.

The public health infrastructure in rural Idaho is not well understood but is potentially the most fragile aspect of the state's health care system. The rural environment, especially typical in Idaho where agriculture, manufacturing, and fishing are important or dominant parts of the economy, presents extraordinary threats to health. Agriculture brings the use of pesticides and herbicides as well as heavy and potentially dangerous machinery. Manufacturing – depending on the type – is a consistently hazardous industry, and employees involved in fishing and forestry are at much higher risks of trauma. Healthcare and in particular a focus on rural health, provides significant opportunities for economic development in Idaho. Partnerships with private entities in the healthcare industry, funding though the National Institutes of Health and other federal agencies utilize the natural laboratory of Idaho's rural population. Idaho's universities' contributions towards this emerging area of scholarship will add to the global competitiveness of the United States and the State.

Novel Materials: The global materials industry is worth an estimated $550 billion, conservatively. Materials revolutionize our lives by offering advanced performance and new possibilities for design and usage. For example, the market for biocompatible materials has grown from a few to $60B in the past decade. Market size is growing for materials in emerging areas such photonic materials, electronic and dielectric materials, functional coatings, and green materials. Materials research in Idaho is conducted by a wide range of scientists in diverse fields. Across the state, faculty members in Biology, Chemistry, Geosciences, Physics, Electrical Engineering, Mechanical Engineering , Nuclear Engineering and Materials Science and Engineering conduct research on improving and developing new materials. Current materials researchers in Idaho cover a broad spectrum of specializations, including semiconductor device reliability, microelectronic packaging, shape memory alloys, DNA machinery, environmental degradation, materials for extreme environments, biomaterials and bio-machinery, materials characterization, and materials modeling. Nanoscale materials and devices, functional materials and their uses and materials for energy applications are a focus of research throughout the state. These areas of research are highly synergistic with local industries and the Idaho National Laboratory (INL). Access to materials characterization equipment and processing laboratories has resulted in collaborations with small businesses and start-up companies.

Systems Engineering and Cybersecurity: Device control , information management, and cybersecurity are an essential part of 21st century life and, therefore, are an important part of educational requirements. For instance, large amounts of sensitive data are collected, processed, and stored electronically but must be accessed and moved in order to have any impact. In fact, many systems are computer controlled through networks. These include such things as the electric transmission grid and transportation in major cities. The universities are beginning to develop research expertise in software development and data management lifecycle design and operations and secure and dependable system design and operations. This area provides a significant area of opportunity for positive economic impact in Idaho, partnerships with the Idaho National Laboratory, and in improving the global competitiveness of the United States. There are already a significant number of firms in Idaho whose interests are in software development for device control, information management and processing. In addition, many of the major research projects being undertaken in the region by various state and federal agencies as well as the universities require the handling of significant amounts of data in a secure and dependable fashion. Currently, research funding in the universities from private and governmental sources is limited by the number of qualified personnel. In addition, within Idaho there is a high demand for graduates at all levels in computer science, hence workforce development in these areas should be a matter of urgency.

EXTERNAL FACTORS: IDAHO RESEARCH ADVANTAGESAND CHALLENGES

There are unique advantages and challenges to research in Idaho. This document seeks to provide guidance on building upon the advantages present in Idaho and address the challenges through the goals in this strategic plan.

Research Advantages

The Idaho National Laboratory (INL) and the Center for Advanced Energy Studies: Idaho is fortunate to be home to the Idaho National Laboratory, one of only 17 U.S. Department of Energy national laboratories in the U.S. The INL's unique history and expertise in nuclear energy, environmental sciences and engineering, alternative forms of energy, and biological and geological sciences and related fields provides an excellent opportunity for research collaboration with Idaho's university faculty in the sciences, engineering, business and other fields.

The Center for Advanced Energy Studies (CAES), established at the request of the U.S. Department of Energy, is a public-private partnership that includes Idaho's research universities (Boise State University, Idaho State University, and the University of Idaho), the University of Wyoming, and the Battelle Energy Alliance (BEA), which manages the INL. The CAES partners work together to create unique educational and research opportunities that blend the talents and capabilities of Idaho's universities and the INL. A 55,000 square-foot research facility in Idaho Falls supports the CAES energy mission with laboratory space and equipment for students, faculty, and INL staff in collaborative research projects. The State of Idaho invests $3M per year in direct support of the three Idaho research universities.

Natural Resources: Idaho's beautiful natural resources are well known to fishermen, hunters, skiers, and other outdoor enthusiasts. Through its rivers, forests, wildlife, geological formations, and rangelands, Idaho itself is a unique natural laboratory for geological, ecological, and forestry studies. Idaho is home to some of the largest tracts of remote wilderness in the lower 48 states. In addition, the proximity of Yellowstone National Park and the Great Salt Lake provide additional one of a kind opportunities for ecology and geology research.

Small Population: Idaho's relatively small population of 1.6 million people enables every group in the state to be included in research surveys, providing more accurate information than a sampling of only some groups.

Intrastate Networks: The existing networks within the state, including agricultural extension services and rural health networks, provide a foundation for collecting research data from across the state, and rapidly implementing new policies and practices as a result of research discoveries.

Research Challenges

The goals set forth in this strategic plan are specifically designed to address challenges in Idaho. These challenges are identified below and include a description of the challenge and the goal from this strategic plan that addresses that specific challenge.

Lack of Coordination Among Universities In Advancing Research and Economic Development (technology transfer): By and large the research universities have not coordinated and shared their technology transfer and economic development activities among themselves. This not only decreases each university's competitiveness at the national and state level but also increases the costs for achieving a particular goal. There is some redundancy in programs, services and infrastructure between the universities. This duplication both limits the success that any one university can achieve and increases the cost.

Historical Competition Between Universities: One of the greatest problems with growing the research and economic development enterprise within the Idaho university arena has been the competitiveness between research universities. This problem existed at all levels within the universities themselves, extended through university administration to the state level, and was even prevalent in the press. While competition between the universities is to be expected when all are competing for a finite pot of money within the state and is even healthy at some level, the level of competition was counterproductive. The real competition that Idaho universities face is other universities in the United States when it comes to research dollars and attracting faculty and students. Economic development is also not a competition between the state universities but rather a competition with other states.

Goal 1 is designed to remedy these two challenges by “increas(ing) 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.”

Competition from Other Universities: In research, university faculty competes nationally for grant funds from federal agencies such as the National Science Foundation, Department of Energy, and the Department of Health and Human Services. Many other states’ universities are well ahead of Idaho’s universities in terms of state funding per student, patent royalty income, endowments, etc., and are able to move ahead at a faster pace, leaving Idaho universities further behind as time goes on.

Goals 1 and 2 are designed to make Idaho’s research universities more competitive nationally and globally through collaboration with each other and by “(strengthening) the relationship between state universities and the private sector.”

University Culture: Each of Idaho’s research universities aspires to greater levels of achievement in research and creative activity, yet many faculty at each of the universities are not fully engaged on a national level in their respective fields. This is changing for the better under new leadership and with new research-active faculty hires at each institution, but these cultural differences remain, resulting in discomfort with change aimed at making the universities more nationally competitive.

While Goal 1 urges the researchers at Idaho’s universities to keep a national and global vision for their research, Goal 4 aims to enhance the research capabilities of faculty by “(enhancing) learning and professional development.”

Private Sector Support: Idaho has very little high-technology industry within its borders. This reduces the potential for developing an applied research initiative within the universities that, in many states, provides one important arm of economic development and technology transfer. This also means that it is much harder to develop those private/public partnerships that provide the universities with additional capital to construct research are technology transfer facilities.

The private sector plays a critical role in research. Goal 2 states that we will "create research and development opportunities that strengthen the relationship between state universities and the private sector."

Fragmented Economic Development Initiatives: There are seemingly too many economic development initiatives in Idaho and they are not well coordinated. It is imperative that state, university, and community initiatives work together toward common and agreed to goals. As it is, little progress is being made towards developing an economic strategy for the state that includes the research universities and little money has been secured to drive the economic development process. In fact, it is not uncommon to find that different entities in Idaho are competing against each other.

Positive economic impact is the result of well-organized and collaborative research. It requires strategic planning and execution. Goal 3 indicates that Idaho's research universities focus on "(contributing) to the positive economic impact of the State of Idaho."

Conclusion

This statewide Strategic Research Plan for Idaho Higher Education provides a framework to mitigate these external challenges and help Idaho institutions continue to focus on their research strengths. Overcoming the challenges discussed in this document will require enhanced cooperation between the functional groups at each Idaho university, fueled by a desire to work together towards the common goal of improving Idaho's economy for future generations.

HIGHER EDUCATION RESEARCH COUNCIL - 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	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	Not yet available		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	Not yet available		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		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		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.					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	Benchmark
Number of new sponsored projects involving the private sector.	165	163	172		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**	**Benchmark**
Number of technology transfer agreements (as defined by AUTM [Association of University Technology Managers]).	44	33	29		15% annual increase
Number of invention disclosures (including biomic varieties)	40	38	45		1 for every $2M of research expenditures
Amount of licensing revenues.	$724,316	$1,271,819	$ 1,869,718		10% annual increase
Number of startup companies.	8	1	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**	**Benchmark**
Number of undergraduate students paid from sponsored projects.	1,683	1,811	2,100		20% annual increase
Number of graduate students paid from sponsored projects.	636	716	656		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: 65.95%, BSU: N/A, ISU: 12.1%	UI: 62.71%, BSU: N/A, ISU: 19.56%		20% annual increase
Number of faculty and staff paid from sponsored projects.	2,272	2,383	2,418		20% annual increase

Boise State University

Sponsored Project Activity Report FY201

9*Awards for the Period July 1, 2018 through June 30, 2019*

Activity Type	Federal	State	Industry	Other	Total	% of Grand Total
Instruction:						
Sponsored Programs	$ 2,062,520	$ 1,147,002	$ -	$ 3,500	$ 3,213,022	
State Instruction Appropriations	$ -	$ -	$ -	$ -	$ -	
Subtotal Instruction	$ 2,062,520	$ 1,147,002	$ -	$ 3,500	$ 3,213,022	6.00%
Research:						
Sponsored Programs	$ 28,301,973	$ 1,098,917	$ 303,759	$ 1,103,710	$ 30,808,359	
State Research Appropriations	$ -	$ 753,500	$ -	$ -	$ 753,500	
Subtotal Research	$ 28,301,973	$ 1,852,417	$ 303,759	$ 1,103,710	$ 31,561,859	58.98%
Other Sponsored Activities:						
Sponsored Programs	$ 12,812,501	$ 4,818,549	$ 5,800	$ 1,028,602	$ 18,665,452	
State Other Sponsored Activities Appropriations	$ -	$ 70,011	$ -	$ -	$ 70,011	
Subtotal Other Sponsored Activities	$ 12,812,501	$ 4,888,560	$ 5,800	$ 1,028,602	$ 18,735,463	35.01%
Grand Totals	**$ 43,176,995**	**$ 7,887,978**	**$ 309,559**	**$ 2,135,811**	**$ 53,510,344**	
Percent of Grand Total	***80.69%***	***14.74%***	***0.58%***	***3.99%***	***100%***	***100%***

Expenditures for the Period July 1, 2018 through June 30, 2019

Activity Type	Federal	State	Industry	Other	Totals	% of Grand Total
Instruction:						
Sponsored Programs	$ 3,252,352	$ 1,613,546	$ -	$ 285	$ 4,866,183	
State Instruction Appropriations	$ -	$ 0	$ -	$ -	$ 0	
Subtotal Instruction	$ 3,252,352	$ 1,613,546	$ -	$ 285	$ 4,866,183	10.74%
Research:						
Sponsored Programs	$ 24,331,657	$ 1,566,725	$ 236,278	$ 877,179	$ 27,011,840	
State Research Appropriations	$ -	$ 577,684	$ -	$ -	$ 577,684	
Subtotal Research	$ 24,331,657	$ 2,144,409	$ 236,278	$ 877,179	$ 27,589,523	60.89%
Other Sponsored Activities:						
Sponsored Programs	$ 8,556,739	$ 2,570,520	$ 23,606	$ 1,702,384	$ 12,853,249	
State Other Sponsored Activities Appropriations	$ -	$ -	$ -	$ -	$ -	
Subtotal Other Sponsored Activities	$ 8,556,739	$ 2,570,520	$ 23,606	$ 1,702,384	$ 12,853,249	28.37%
Grand Totals	**$ 36,140,748**	**$ 6,328,475**	**$ 259,884**	**$ 2,579,849**	**$ 45,308,956**	
Percent of Grand Total	***79.77%***	***13.97%***	***0.57%***	***5.69%***	***100%***	***100%***

Idaho State University
Office for Research
Award Breakdown by Funding Agency Type and Project Type
July 1, 2018 through June 30, 2019

	Federal	State	Industry	Other/Foundation	Totals	Percent of Total
Research	2,329,990	2,463,159	3,072,095	1,013,812	8,879,056	43%
Training and Instruction	4,383,298	1,202,532	1,140,725	260,069	6,986,624	34%
Other/Public Service	500,748	2,527,950	811,914	945,579	4,786,191	23%
Totals	7,214,036	6,193,641	5,024,734	2,219,460	20,651,871	100%
Percent of Total	35%	30%	24%	11%	100%	

File Name: ISU OR Annual Awards FY19

IDAHO STATE UNIVERSITY

SPONSORED PROJECT EXPENDITURE REPORT

8/13/2019

FY2019

AMOUNT PER FUNDING TYPE

Expenditures for the Period July 1, 2018 through June 30, 2019

	Federal	State	Industry	Other	Totals	
Research	$8,062,302	$690,851	$721,101	$205,041	$9,679,295	48%
Training and Instruction	$5,907,648	$1,383,650	$517,550	$28,651	$7,837,499	39%
Other/Public Service	$1,374,609	$482,039	$607,900	$18,496	$2,483,043	12%
Totals	$15,344,558	$2,556,540	$1,846,551	$252,187	$19,999,837	
Percent of Total	77%	13%	9%	1%	100%	100%

University of Idaho - FY2019 Research Activity Report

Awards for the Period July 1, 2018 through June 30, 2019

	Federal	State of Idaho	Industry	Other	Total	% of Grand Total	% of Sponsor Total
Instruction:							
Sponsored Programs	$ 2,497,394.00	$ 64,369.59	$ 92,999.90	$ 44,000.00	$ 2,698,763.49		**3%**
	$ 2,497,394.00	$ 64,369.59	$ 92,999.90	$ 44,000.00	$ 2,698,763.49	**2%**	
Research:							
Sponsored Programs	$ 53,743,697.45	$ 3,314,312.00	$ 2,434,898.39	$ 4,164,441.24	$ 63,657,349.08		**73%**
Federal Land Grant Appropriations (FFY19)	2,912,154.00				2,912,154.00		
State Research Appropriations (CALS,FUR,IGS,EPSCoR)		22,821,259.88			22,821,259.88		
Subtotal Research:	$ 56,655,851.45	$ 26,135,571.88	$ 2,434,898.39	$ 4,164,441.24	$ 89,390,762.96	**70%**	
Public Service:							
Sponsored Programs	$ 17,455,143.05	$ 1,603,160.96	$ 12,170.40	$ 1,669,521.86	$ 20,739,996.27		**24%**
Federal Land Grant Appropriations (FFY19)	3,056,251.00				3,056,251.00		
State Extension Appropriations		11,665,470.20			11,665,470.20		
Subtotal Public Service:	$ 20,511,394.05	$ 13,268,631.16	$ 12,170.40	$ 1,669,521.86	$ 35,461,717.47	**28%**	
Construction:							
Sponsored Programs	-	-	-	-	-	**0%**	**0%**
Total Sponsored Programs Funding	***$ 73,696,234.50***	***$ 4,981,842.55***	***$ 2,540,068.69***	***$ 5,877,963.10***	***$ 87,096,108.84***		
Percent of Total Sponsored Programs	***84%***	***6%***	***3%***	***7%***	***100%***		***100%***
Grand Total of All Funding Per Category	**$ 79,664,639.50**	**$ 39,468,572.63**	**$ 2,540,068.69**	**$ 5,877,963.10**	**$ 127,551,243.92**		
Percent of All Funding	***62%***	***31%***	***2%***	***5%***	***100%***	***100%***	

Expenditures for the Period July 1, 2018 through June 30, 2019 (includes accruals)

	Federal	State of Idaho	Industry	Other	Institutional	Total	% of Grand Total	% of Sponsor Total
Instruction:								
Sponsored Programs	$ 2,069,702.17	$ 3,179.98	$ 89,804.28	$ 281,556.99	$ 443,851.46	$ 2,888,094.88		**3%**
	$ 2,069,702.17	$ 3,179.98	$ 89,804.28	$ 281,556.99	$ 443,851.46	$ 2,888,094.88	**2%**	
Research:								
Sponsored Programs	$ 48,215,835.53	$ 2,895,313.52	$ 1,822,102.18	$ 4,584,402.37	$ 10,123,909.28	$ 67,641,562.88		**74%**
Federal Land Grant Appropriations	3,236,625.21					3,236,625.21		
State Research Appropriations (CALS,FUR,IGS,EPSCoR)		22,843,172.96				22,843,172.96		
State Other Appropriations		8,964,305.49				8,964,305.49		
Other Sources	-		-	2,270,600.76	8,150,910.92	10,421,511.68		
Subtotal Research:	$ 51,452,460.74	$ 34,702,791.97	$ 1,822,102.18	$ 6,855,003.13	$ 18,274,820.20	$ 113,107,178.22	**74%**	
Public Service:								
Sponsored Programs	$ 16,435,726.05	$ 1,242,296.18	$ 7,592.04	$ 1,324,274.15	$ 2,489,654.80	$ 21,499,543.22		**23%**
Federal Land Grant Appropriations	3,056,000.99					3,056,000.99		
State Extension Appropriations		11,665,470.20				11,665,470.20		
Subtotal Public Service:	$ 19,491,727.04	$ 12,907,766.38	$ 7,592.04	$ 1,324,274.15	$ 2,489,654.80	$ 36,221,014.41	**24%**	
Construction:								
Sponsored Programs	$ -	$ -	$ -	$ -	$ -	$ -	**0%**	**0%**
Total Sponsored Programs Funding	$ 66,721,263.75	$ 4,140,789.68	$ 1,919,498.50	$ 6,190,233.51	$ 13,057,415.54	$ 92,029,200.98		
Percent of Total Sponsored Programs	*73%*	*4%*	*2%*	*7%*	*14%*	*100%*		100%
Grand Total of All Funding Per Category	$ 73,013,889.95	$ 47,613,738.33	$ 1,919,498.50	$ 8,460,834.27	$ 21,208,326.46	$ 152,216,287.51		
Percent of All Funding	*48%*	*31%*	*1%*	*6%*	*14%*	*100%*	100%	

FY19 Infrastructure Report Summary - Boise State University

Detailed Allocations	
Library Support	
Graduate Research Assistantships/Research Associates	
Post Doctoral Fellows	
Technician Support	
Maintenance Contracts	8,500
Research Equipment	92,243
Competitively Awarded Summer Research Support	87,447
Start-Up Funds for New Hires	60,000
Incentives to Reward Faculty for Research Achievements	
Other	

FY19 Infrastructure Report Summary - Boise State University

Total Allocation	248,190

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	

FY19 Infrastructure Report Summary - Boise State University

Notes:

Research Equipment:

City Center Plaza Conference Room Equipment for Computer Science

Art Department Easels

Bruker BioSpin Console digital temp control unit for physics instrument

CS - Nodes for R2 compute / server

Startup funds / New hires:

Lisa Warner, Chemistry

Summer Research support

Laura King, School of Public Service

Maintenance Contract

Research Computing Charges AWS

FY19 Infrastructure Report Summary - Idaho State University

ISU FY 2019	Total $	Detailed Allocations
Library Support	$0	
Graduate Research Assistantships / Research Associates	$0	
Post-Doctoral Fellows	$0	
Technician Support	$85,921	for the Molecular Research Core Facility and the Stable Isotope Lab
Maintenance Contracts	$72,378	For the Molecular Research Core Facility and Chemistry - LCMS
Research Equipment	$12,968	Stable Isotope Lab - equipment, Chemistry, LCMS
Competitvely Awarded Summer Research Support	$0	n/a
Start-Up Funds for New Hires	$0	n/a
Incentives to Reward Faculty for Research Achievements	$0	n/a
Other	$78,733	The Research Data Center was provided money for operation and license renewal the a new van was purchased for the animal facility, repairs on equipment and facilities were made on the Microscopy lab in Eames
Total Allocation	$250,000	

FY19 Infrastructure Report Summary - Idaho State University

ISU FY 2019	
Publications in Refereed Journals	N/A
Presenations at Professional Meetings and Conferences	N/A
Grants Received as a Result	$75,000 to GISTReC using the RDC. $800,000 to Engineering, use of the Microscopy lab in Eames
Grants Pending	$20,000 RDC
Student Participation	N/A
Faculty Participation	4
Other Participation	n/A
Patents Awarded	N/A
Patents Pending	N/A

Lewis-Clark State College: FY 2019 INFRASTRUCTURE REPORT SUMMARY

	Total $	Detailed Allocations
Library Support	$23.113.00 (Special Projects)	1. PO Number 60485 Nature, England, OL Journal 2019 $10,533.79; 60503 Cell $5,139.21. **TOTAL** $15,673.00
		2. PO Number 816599 Richard Miller - 2019 and Marketing Collection $ 900.00 815938 Global Road Warrior $500.00 386831 Encyclopedia of Nursing Research, EBSCOhost, 3 Users $375.00 386831 Encyclopedia of Elder Care, EBSCOhost, 3 Users $330.00 60344 Gender Roles in American Life: A Documentary $198.00 60344 International Cookbook of Life-Cycle Celebration $105.00 818224 Gale Ebooks $2,500.00 **TOTAL** $4,908.00
		3. PO Salem: Critical Insights: Civil rights literature, past and present; Geoffrey Chaucer; Social Justice and American Literature; Macbeth; Inequality; Censored & banned literature; survival; Martin Luther King Jr. **TOTAL $786.00**
		4. PO Midwest: (818774) Norton Anthology of World Lit 6 volumes; (818420) History of American Working Class literature; Prose fiction in English from the origins of print to 1750; Cambridge history of modernism; 100 great war movies; Silenced in the library; Seeing through the screen; Palgrave Handbook for Climate History. **TOTAL $1,246.00**
		5. PO Ebsoc/YBP 60344. Horror Literature through history; Communicating science, The American Superhero, For the gay stage. **TOTAL $500.00**
Graduate Research Assistantships / Research Associates	8,000.00	Annual Lewis-Clark State College Research Symposium.
Post-Doctoral Fellows	-	N/A
Technician Support	-	N/A
Maintenance Contracts	-	N/A
Research Equipment	$86,650 - one time hardware for Movement & Sport Sciences,	Equipment to support faculty-student research in 12-Mega pixel optical camera, Vicon Vue Video Camera, Lock Lab Control box, 37 ways lock for signal connector, Vicon Active Calibration Wand, 26 Port PoE Gigabit Switch, Ethernet Cable, Dual Video PC, 2-Dell Monitor, Custom Speedrail System, 12-Manfrotto 035 Super Clamp, Small Tripod, 13-Microball Cameras, Basic Life Science Accessory Kit, Extended Life Science Accessory Kit, Vixon Nexus 2.0 Standalone Software Pkg, Polygon 4 Network, Vicon Premier Plan A Support Plan.
	$21,200.00 Independent Research/ GIS lab, one-time hardware	HERC funds were used to purchase 13 computers for the GIS & Image Analysis Center in MLH 115. Eleven of these computers were outfitted with GoogleEarth, GIS, and AQTESOVE software. Two of the computers were set up as LINUX machines for mathematical computational tasks with OCTAVE, GIS, and LaTeX software. The eleven GIS machines have been used to teach GIS courses. In addition, these machines have been used for community outreach projects.

Lewis-Clark State College: FY 2019 INFRASTRUCTURE REPORT SUMMARY

<table>
<tr><td></td><td>$21,600 Library hardware</td><td>HERC Funds were specifically used to replace outdated technology equipment that primarily serves the LCSC student population. This included replacement of 18 student patron usage desktop computers, acquisition/replacement of 5 student used laptops (this included protective briefcases), and purchase of a new, more efficient, color printer. The Library also took the opportunity to procure 2 flat screen TVs (with mounting hardware), and install them in two of the Library study rooms. These television's main purpose is to increase student collaboration on research projects and offer the LC students another avenue to advance their studies.</td></tr>
<tr><td>Competitively Awarded ~~Summer~~ Research Support [completed during academic year]</td><td>-</td><td>N/A</td></tr>
<tr><td>Start-Up Funds for New Hires</td><td>-</td><td>N/A</td></tr>
<tr><td>Incentives to Reward Faculty for Research Achievements</td><td>8,817.07</td><td>
<table>
<tr><th>Name</th><th>Total Amount</th></tr>
<tr><td>Nancy A. Johnston</td><td>$ 295.00</td></tr>
<tr><td>Eric Stoffregen</td><td>$ 246.67</td></tr>
<tr><td>Erin Cassetto</td><td>$ 500.00</td></tr>
<tr><td>Heather Marlowe Daly-Galeano</td><td>$ 100.00</td></tr>
<tr><td>Rebecca Fromdahl</td><td>$ 25.75</td></tr>
<tr><td>Bonnie Schacher</td><td>$ 111.65</td></tr>
<tr><td>Lachelle Rosenbaum</td><td>$ 600.00</td></tr>
<tr><td>Dawn Taylor</td><td>$ 450.00</td></tr>
<tr><td>Nancy A. Johnston</td><td>$ 356.00</td></tr>
<tr><td>Charles Addo-Quaye</td><td>$ 500.00</td></tr>
<tr><td>Eric Stoffregen</td><td>$ 2,819.00</td></tr>
<tr><td>Nancy A. Johnston</td><td>$ 1,315.00</td></tr>
<tr><td>Alicia Robertson</td><td>$ 180.00</td></tr>
<tr><td>Taryn Cadez-Schmidt</td><td>$ 50.00</td></tr>
<tr><td>Samual (Seth) Long</td><td>$ 1,000.00</td></tr>
<tr><td>Barbara Leachman</td><td>$ 40.00</td></tr>
<tr><td>Bill Frei</td><td>$ 228.00</td></tr>
</table>
</td></tr>
<tr><td>Other</td><td>10,545.60</td><td>IR&E Qualtrics Licenses ($6500.00), SPSS Campus-wide licenses ($4,045.60)</td></tr>
<tr><td>Publications in Refereed Journals</td><td>-</td><td>N/A</td></tr>
<tr><td>Presentations at Professional Meetings and Conferences</td><td>6,025.00</td><td>Charles Addo-Quaye ($1500.00) Improving the accuracy of silico DNA mutation detection methods - - Amy Canfield ($1885.00) Popular culture association American culture association conference. Participated in a panel, presented paper "Cesspool-type antics: Elvis Presley, Teenage Rebellion, and the 'Generational' Divide. Nancy Johnston ($1500.00) Traveled to the American Geophysical Union conference in Washington, D.C. Nancy and students presented a research poster titled "Seasonal Observations of Atmospheric Volatile Organic and Sulfide Compounds near a Pulp Paper Mill in North-Central Idaho". Manee Moua ($570.00) Presented research paper and proposal at the 2019 Hawaii International Conference on Education. This conference promotes pedagogical education and practices. She brought awareness to the importance of creating mentor and mentee relationships that are culturally inclusive to our underrepresented and first generation students. LaChelle Rosenbaum/Marte White ($570.00) Assessing the Social Work Hybrid Program's Intensive Weekend Sessions. Presented at the Social Work Distance Education Conference in San Antonio, Texas.</td></tr>
</table>

Lewis-Clark State College: FY 2019 INFRASTRUCTURE REPORT SUMMARY

Grants Received as a Result	-	N/A
Grants Pending	-	N/A
Student Participation	2,270.00	Doug Cruthirds ($570.00) Giving students the chance to conduct semi-structured interviews and participate in a unique part of the research process. $1,700 Funding for undergraduate research under the direction of Seth Long was used as research salary for DeLaney Jones who has been developing (in collaboration with Jesse McDonald) a novel method of retinal neuron tracing, with the intent of producing a computer program that will allow widespread use of our method. DeLaney presented a poster on it at the IDAHO INBRE conference in Moscow. DeLaney tested linear regression based outlining during Summer 2018, but INBRE fellowship, but at the end of the Summer it still had a number of bugs (this is common in software development) and was not ready for our collaborators at UI to try. The $1,700 awarded to DeLaney Jones for the past academic year was used to develop her method into a useful program, which she tested this Summer using INBRE funds from my pilot project. The HERC funding filled a critical gap between the end of INBRE fellowship support last Summer, and the beginning of my pilot grant this Spring. Because of this funding, DeLaney, Jesse, and Seth were able to put together a manuscript that will be submitted soon.
Faculty Participation	10,405.00	**Kylee Britzman ($570.00)** Studying the effects of political polarization in campaigns. **Marlowe Daly-Galeano ($2600.00)** Research travel to Boston to visit the Houghton Library. Accessed several collections, The Louisa May Alcot papers. The main focus was May Alcott Nieriker's unpublished 1873 manuscript, "An Artist's Holiday" (MS 1817). **Heather Moon (with Keegan Schmidt)($1500.00)** Creating a multidisciplinary, student-centered research program using mathematical techniques for remote sensing of planetary structures that will be ongoing and active. **Keegan Schmidt (with Heather Moon) ($1500.00)** Creating a multidisciplinary, student centered research program in remote sensing and planetary structure: geoscience aspects. Undertook a review of existing literature on remotely sensing rock layers and calculating their orientations. **Amanda Van Lanen ($3000.00).** Research for her book Picking Apples: Orchards and Industrial Agriculture in Washington State. Traveled to Yakima Valley Museum to research extensive library of records relating to the Yakima Horticultural Union. Visited the Wenatchee Valley Museum and Cultural Center. Traveled to the Minnesota Historical Society, which houses the corporate records for the Great Northern and Northern Pacific Railways. **Pete Van Mullem ($1235.00)**. Provided funding to cover travel expenses to Iowa/Kansas to conduct interviews and observation for ongoing book project. Interviewed 18 individuals they knew and worked with the individual (key character) in the book.
Other Participation	1,500.00	**Matt Brady ($1500.00)** Purchased an additional parabolic microphone with professional grade recorder for use in field research and classroom.
Patents Awarded	-	N/A
Patents Pending	-	N/A
Total Allocation	**Allocation $200,000 ; expended $200,126.00**	

FY 2019
INFRASTRUCTURE REPORT SUMMARY - Univ of Idaho

	Total $	Detailed Allocations
Library Support	$0	
Graduate Research Assistantships / Research Associates	$878	I month graduate student payroll
Post-Doctoral Fellows	$2,073	$2,073 for Post-doc to attend conference.
Technician Support	$41,505	$1,182 - Glass Blower provides repair and construction services to UI labs; $32,854 - Mass Spectrometry Director provides research support to UI labs; $7,468 - Optical Imaging Director provides research support to UI labs
Maintenance Contracts	$0	
Equipment	$123,055	$40,000 infrastructure upgrade at CRC to increase data storage, security, and speed of accessibility for researchers using computing resources; $73,055 NKN equipment upgrades; $10,000 for helium recovery system.
Start-Up Funds for New Hires	$0	
Incentives to Reward Faculty for Research Achievements	$6,325	Excellence in Research Award
Other	$76,164	$2,247 for PostDoc/Faculty Mentor Award; $21,980 for microscopy equipment repairs; $4,897 for existing Aquaculture building hookup to the new building's generator; $12,976 student payroll expenses for Virtual Fence project (reducing energy to run system and cost to purchase system by ranchers/rangeland conservationists); $10,000 publishing support; $5,733 to develop shared resources for core service centers; $8,331, conference and travel expenses related to cyber infrastructure; $10,000 to upgrade new space for Stillinger Herbarium.
Total Allocation	$250,000	

FY 2019

INFRASTRUCTURE REPORT SUMMARY - Univ of Idaho

	Detailed Allocations
Publications in Refereed Journals	8
Presenations at Professional Meetings and Conferences	2
Grants Received as a Result	4
Grants Pending	0
Student Participation	13
Faculty Participation	16
Other Participation	14
Patents Awarded	0
Patents Pending	0

NOTE:

Higher Education Research Council Fellowship
Boise State University
Final Report

Academic Year 2018-19

Donna Llewellyn, Executive Director, Institute for STEM & Diversity Initiatives
Catherine Bates, Assistant Director, Institute for STEM & Diversity Initiatives


BOISE STATE UNIVERSITY

Idaho State Board of Education

Introduction

The Institute for STEM & Diversity Initiatives administered the HERC Fellowship at Boise State University for Fall 2018, and Spring 2019. All STEM department chairs were notified of the HERC Research Fellowship application. The application was also disseminated to all STEM undergraduate students. We had 106 students apply for Fall 2018, Spring 2019 positions. Fall 2018, 8 students were awarded the HERC fellowship and 12 students were awarded the fellowship in the spring semester.

HERC Fellows from Boise State represented 12 different academic departments and were almost all first-time student researchers. We supported five students from traditionally underrepresented minority populations. HERC fellows primarily presented final research projects at either the Undergraduate Research Conference or the Idaho Conference of Undergraduate Research at Boise State University. Kelly Mazur presented her research at the 2019 Idaho Chapter of American Fisheries Society Annual Meeting, held in Boise, Idaho. Alex Schweitzer presented his research at the American Geophysical Union meeting in Washington DC. Nicole Clizzie presented at the 2019 Seismological Society of America Annual Meeting, held in Seattle, Washington. And finally, 10 students attended the Pacific Sociological Association annual conference in Oakland, CA. Students and faculty mentors are from a variety of disciplines (please see below).

A previous Boise State HERC Fellow, Melissa Roberts, was a co-author on a paper published in June 2019 in the peer-reviewed journal, *Scientific Reports*. Her work during her 2016 HERC fellowship appointment was included in this paper. The HERC Fellowship was also acknowledge in the paper. You can access her publication here: https://www.nature.com/articles/s41598-019-45310-z. Also, here is the press release of this accomplishment in Boise State's Campus Update: https://www.boisestate.edu/news/2019/06/26/researchers-cook-up-chemical-reactions-in-primordial-soup/

On behalf of the Institute for STEM and Diversity Initiatives, we thank the Higher Education Research Council for their generous support in helping build meaningful learning experiences for our undergraduate students.

HERC Funding:

The Higher Education Research Council provided $55,000 to support undergraduate students in their pursuit of faculty mentor supported undergraduate research experience. Please see table below of how stipends and travel awards were dispersed.

Stipends	**Amount**
Fall 2018 Research Stipends	$24,000
Spring 2018 Research Stipends	$26,000
Student Travel to Professional Conference	**Amount**
Pacific Sociological Assoc. Conference (10 students)	$5,000
Total	**$55,000**

Fall 2018, Spring 2019 Undergraduate Research Fellows and Discipline

Student Name	Gender	Ethnicity	Race	STEM Major	Type of Award
Linda Choi	F	Non Hispanic/Latino/a	Asian	Mechanical Engineering	Research
Nicole Clizzie	F	Non Hispanic/Latino/a	Native American	Geosciences	Research, Travel
Thomas Conrad	M	Non Hispanic/Latino/a	Caucasian	Health Sciences	Research
Kim Farrar	F	Non Hispanic/Latino/a	Caucasian	Chemistry	Research
Nathan Imonigie	M	Non Hispanic/Latino/a	African American	Biology	Research
Devan Karsann	M	Non Hispanic/Latino/a	Caucasian	Computer Science	Research
Lola Klamm	F	Non Hispanic/Latino/a	Caucasian	Biology	Research
Sandra Lira Ambriz	F	Hispanic/Latino/a	More than one race	Computer Science	Research
Danielle Marquette	F	Non Hispanic/Latino/a	Caucasian	Geosciences	Research
Kelly Mazur	F	Non Hispanic/Latino/a	Caucasian	Biology	Research
Elena Paz Munoz	F	Hispanic/Latino/a	More than one race	Chemistry	Research
Julie Ramirez	F	Hispanic/Latino/a	Caucasian	Environmental Studies	Research
Alex Schweitzer	M	Non Hispanic/Latino/a	Caucasian	Geosciences	Research
Joey Tuccinardi	M	Non Hispanic/Latino/a	Caucasian	Chemistry	Research
Malyk Walker	M	Non Hispanic/Latino/a	African American	Health Science, Pre-Med	Research
Ariel Weltner	F	Non Hispanic/Latino/a	Caucasian	Materials Science Engineering	Research
Donovan Wright	M	Non Hispanic/Latino/a	Caucasian	Computer Science	Research

Pacific Sociological Association (PSA) Conference Attendees—HERC Travel Award

Student Name	Discipline	Award Received
Alejandro Andonaegui	Psychology	Travel
Jeff Cates	Sociology	Travel
Michelle Fretwell	Sociology	Travel
Jessica Gaston	Psychology	Travel
Yasmine Goodman	Ethnic Studies	Travel
Allyssa Hernandez	Sociology	Travel
Ramona Hinrichs	Sociology	Travel
Aaron Lampe	Sociology	Travel
John Ropp	Communication	Travel
Patrick Wangoi	Sociology	Travel

Fall 2018 HERC Fellow Student Abstracts:

Sandra Ambriz
Faculty Mentor: Dr. Michael Ekstrand, Department of Computer Sciences
Research Title: Gender Bias in Word Embeddings

Common word embeddings, which allow words to be individually represented in vector form, have demonstrated to possess gender bias. In particular, the bias found in the Word2Vec and the GloVe word embeddings were explored. The Word2Vec and GloVe embeddings are commonly-used and their gender bias has been previously demonstrated to exist. Gender bias was argued to have been found in these embeddings by studying the cosine similarities of the vector word representations. Removing harmful word associations, while keeping desired word associations, from the word embeddings would eliminate gender bias. After loading the Word2Vec and GloVe data, the gender direction was defined, and a dataset of occupation words were projected onto that direction. The gender direction consisted of the words he and she (he-she) due the lack of multi-meaning associated with those specific gendered words. Given the gender direction and the projection of the occupation words, stereotypicality estimates were derived using word correlations. Using these techniques, gender bias was found to be present in both the Word2Vec and GloVe embeddings.

Linda Choi
Faculty Mentor: Dr. Zhanxian Deng, Department of Mechanical & Biomedical Engineering
Research Title: Flexible Piezoelectric Force Sensor Monitoring Pianist Performance

Piano beginners need to spend their first few months on properly pressing the keyboard.
Proper fingering and correct hand position ensure that notes are played with the same rhythm, flow and power. Without a professional teacher, this practice can be challenging. In this research project, a smart glove with a flexible and in-situ Polyvinylidene Fluoride (PVDF) sensor was designed to track the force on the piano students' finger tips in real time. Compared with existing resistive, capacitive, and semiconductor force sensors, PVDF sensors are superior in accuracy, sensitivity, mechanical robustness, lightweight, and corrosion resistance. The measurement range and frequency bandwidth of the new PVDF sensor were first calibrated by using a commercial piezoelectric force sensor. The calibrated PVDF sensor was then glued on a rubber glove and tested during actual piano playing. Due to the help of this smart glove, piano students can evaluate their own

performance by comparing the force measurement with the suggested data without a professional teacher. The same force sensing concept can be implemented as artificial skin of future robots.

Nicole Clizzie
Faculty Mentor: Dr. Lee Liberty, Department of Geosciences
Research Title: Shear-wave Velocity and Seismic Response Estimates From the Southern Isoseismal Region of the 1886 Charleston Earthquake: Results From a Seismic Land Streamer System
The 1886 M~7 earthquake damaged Charleston's infrastructure and killed more than 100 people. Today, ground amplification from a similar earthquake would devastate the region. For this fault mapping and site response study, we acquired 14 km of seismic data over five field days using a 72-channel, 90 m land streamer/accelerated weight drop system along city streets. The data collection was located within the southern isoseismal zone of the 1886 earthquake. We acquired shots every 2.5 m to obtain more than 5,000 dispersion curves and 360,000 first arrival picks. We estimate shear wave velocity (Vs) from phase velocity-frequency picks for the fundamental mode using a range of inversion approaches. We estimate p-wave velocity (Vp) by inverting first arrival picks. For our site response analysis, we assume a two-layer velocity model that represents Holocene sediments over older strata. Because Vp results are sensitive to water saturation that crosses lithologic boundaries, we rely on Vs to map Holocene layer thickness, to estimate resonant frequencies, and to estimate ground surface amplification. We compare our Vs results to mapped geology, layer thickness derived from auger holes, and to coincident seismic reflection results that we generated from the same dataset. We estimate Vs for Holocene sediments, late Pleistocene Wando Formation, middle Pleistocene Ten Mile Formation, and Tertiary Ashley Formation. We find the thickness of Holocene strata lies mostly at depths less than 30 m below the land surface. We suggest that this shallow boundary controls site amplification and that the seismic land streamer approach provides a rapid and effective high frequency site response tool for urban areas.

Thomas Conrad
Faculty Mentor: Dr. Don Warner, Department of Biological Sciences
Research Title: Synthesis of Small Molecule Inhibitors for Metastatic Breast Cancer Pathways

As of 2019, it is predicted that 268,600 women will be diagnosed with breast cancer in the United States and of those diagnosed, 41,760 will lose their lives. More specifically, the Surveillance, Epidemiology, and End Results Database (SEER) measured the 5-year survival rate of localized breast cancer to be 99% compared to a dismal 27% for distant breast cancer. It has been studied that inflammatory cytokines (IC) activate several pathways that have been found to play an active part in promoting the metastasis of breast cancer. This prompted the creation and evaluation of small molecule inhibitors (SMI) for the target IC. Previous work using enzyme-linked immunosorbent assays (ELISA) concluded the small molecule IC-SMI-10 inhibited one of the culpable pathways. The focus of this research is to design and synthesize second generation IC-SMI-10 analogs with greater proclivity for inhibiting the metastatic breast cancer pathway. The goal is to continue creating analogs of specifically IC-SMI-10B with a focus on determining to what degree hydrophobic and hydrophilic interactions are responsible for binding in the IC's active site. These developments are sought to be highly advantageous in preventing metastatic breast cancer.

Kim Farrar
Faculty Mentor: Dr. Michael P. Callahan, Department of Chemistry and Biochemistry
Research Title: Trace Analysis of Wine from 6000 BC

The Neolithic (10,000-3,500 BC) was the age of achievement and expansion. This period represented a transition where food-collecting cultures shifted to food-producing ones, which allowed people to establish year round settlements. Many plants were domesticated including the Eurasian grape, which is believed to be the first grape used to ferment wine. There is an ongoing archeological dig in the Republic of Georgia to investigate the earliest winemaking and the emergence of wine culture as part of the Gadachrili Gora Regional Archaeological Project Excavations (G.R.A.P.E.). Sherds of pottery jars excavated from the dig site, along with corresponding soil samples, were analyzed for the presence of four characteristic grape/wine acids (tartaric acid, citric acid, malic acid, and succinic acid) by high performance liquid chromatography-mass spectrometry. All four acids were detected in trace amounts in every sample; however, there was no significant difference in the amount of acids found in the sherd samples versus the soil samples. As a result, we could not verify the presence of wine in these particular archaeological sherds.

Nathan Imonigie
Faculty Mentor: Dr. Henry A. Charlier, Department of Chemistry and Biochemistry
Research Title: A Potential Role for Methionine-234 in Human Carbonyl Reductase Coenzyme Binding

Anthracyclines are among the most commonly used cancer chemotherapeutic agents; however, treatment is limited by cumulative-dose dependent cardiotoxicity. Human Carbonyl Reductase 1 (HCBR1) catalyzes the NADPH-dependent reduction of anthracyclines to alcohol metabolites that are thought to contribute to the cardiotoxicity. For this reason, HCBR1 is considered to be a potential therapeutic target for lowering the risk of anthracycline-induced cardiotoxicity. A methionine in the active-site of the enzyme, M234, was identified as having the potential to interact with the anthracyclines in a manner that limits the catalytic efficiency for them. To test this hypothesis, M234 was mutated to alanine (M234A). Earlier fluorescence quenching studies revealed M234 may actually impact NADPH binding as the M234A mutant showed lowered binding affinity for NADPH. This observation led to the hypothesis that the $NADP^+$ product may also have reduced binding affinity of M234A mutant. As expected, fluorescence quenching studies confirmed that the $NADP^+$ binding affinity of M234A was significantly lower than that of the native enzyme. This finding suggests that M234 might play a role in coenzyme binding by HCBR1 and have less direct impact on anthracycline binding and orientation than originally believed.

Devan Karsann
Faculty Mentor: Dr. Sole Pera, Department of Computer Science
Research Title: Featureless Approaches for Text Simplification Evaluation

Text simplification, which involves replacing or rephrasing (section of) a document while minimizing meaning loss in order to generate simplified, i.e., easier to understand, versions of said document, has attracted researchers from both natural language processing and information retrieval domains of study. Text simplification has a direct connection to a wide range of applications, from those that demand specific reading comprehension ease, e.g., ensuring legal or medical documents are easy to read and understand, to those focused on making reading materials further accessible for K-12 audiences or English language learners. Evaluating outcomes from existing text simplification techniques, in terms of pairwise correctness of label ranking predictions, is a difficult task because these techniques tend to depend upon domain specific indicators such as lexical, syntactic, morpho-syntactic, and psycholinguistic features. Our hypothesis is that we can perform pair-wise text simplification ranking in a featureless fashion by relying on state-of-the-art learning architectures. . To answer our research question and manage scope, we will use sentences (not full documents) as a case study. Thereafter, we will explore diverse techniques from baselines like Naïve Bayes to well-known, state-of-the-art counterparts based on deep learning. We then will conduct an exhaustive empirical analysis on multiple datasets on feature-based and featureless strategies, in order to demonstrate the validity of our proposed approach.

Lola Klamm
Faculty Mentor: Dr. Marie-Anne de Graaff, Department of Biological Sciences
Research Title: The Effects of Bioenergy Crop Species on Microbial Functioning

With the threat of climate change, there is a growing incentive to reduce atmospheric carbon dioxide (CO2) levels. Soil is the largest sink of terrestrial carbon (C), and the natural processes of soil carbon sequestration could be harnessed to reduce atmospheric CO2. Grasses like switchgrass (*Panicum virgatum*) and big bluestem (*Andropogon gerardii*) have the potential to sequester C since they have extensive root systems, and their cultivation involves little disturbance to the soil. Research in our lab has shown that soil C accumulation differs among cultivars of switchgrass and big bluestem. Additionally, studies have indicated that the microbial community structure and functioning can affect soil C accumulation. However, whether variation among the microbial communities of big bluestem and switchgrass cultivars could be responsible for the observed differences in soil C accumulation is still unknown. This study seeks to understand how cultivars of switchgrass and big bluestem affect microbial functional diversity across a soil depth profile. We collected 30 cm soil cores split into 3 increments from a long-term field experiment in the Fermilab National Environmental Research Park, IL. Microbial functional diversity was analyzed for samples from cultivar monocultures by exposing them to different carbon substrates, incubating, and determining respired CO2.

Danielle Marquette
Faculty Mentor: Dr. Jim Browning, Department of Mechanical & Biomedical Engineering
Research Title: ENVI Classification of Multispectral Images to Track Alfalfa Bloom; Comparing Two Vegetation Indices

Alfalfa seed crop managers must coordinate the release of the crop's pollinators with peak alfalfa bloom to maximize seed yield. High resolution blue, green, and near infrared (NIR) imagery may provide useful information to track alfalfa blooms and better predict the optimal time to release the pollinators. This study used ENVI image analysis software classification methods to quantify blooms in NIR imagery. Two vegetation indices were applied to the images to increase the spectral separability of the flowers and to compare their accuracy. The vegetation indices are GNVI=*(Green-NIR)/(Green+NIR)* and FVI=*(Blue/Green)*(NIR/Green)*. After applying the vegetation indices, regions of interest (ROI's) were selected and used as training data for ENVI's classification algorithms. Three ENVI classifications performed well at identifying and quantifying the blooms from the imagery. The classification methods are Constrained Energy Minimization, Maximum Likelihood, and Support Vector Machine. Constrained Energy Minimization with the FVI vegetation index had the highest accuracy of 98.35%.

Kelly Mazur
Faculty Mentor: Dr. David Pilliod, Department of Biological Sciences

Research Title: Examining Standard Environmental DNA Sample Extraction and Archival Methods

Use of environmental DNA (eDNA) methods for detecting rare and secretive species has become an important tool for biological research and monitoring. Given the recent development of the field and the novelty of the methods employed, however, empirical testing of methods is needed. The goal of our research was to evaluate the handling of filters (used to concentrate DNA during field filtration) prior to and during the DNA extraction process. A common DNA extraction procedure involves splitting a filter sample into equal halves, with one half processed and the other half archived by freezing (at -20C or -80C) in 200-proof molecular grade ethanol. Our first objective was to assess the assumption that eDNA is evenly distributed across both halves of a sample filter. This could have important implications for studies involving quantitative eDNA data. Our second objective assessed the effects freezing and storing the unextracted half of the filter on DNA yield. We tested both objectives using samples collected annually as part of another study dating back to 2012. Preliminary results of this study will be presented, including quantitative, statistical differences in DNA yield from the two halves of each filter within a year, as well as rates of degradation of DNA on stored filters across time (from 0 to 6 years). Results of this study could help improve eDNA laboratory methods and provide insight into proper sample archival procedures, helping to safeguard eDNA archives for future use.

Elena Paz Munoz
Faculty Mentor: Dr. Ken Cornell, Department of Chemistry and Biochemistry
Research Title: MTN Knockout Attenuates Vitamin Synthesis and Global Metabolism in E. coli O157:H7

The microbial enzyme 5'-methylthioadenosine/S-adenosylhomocysteine (MTA/SAH) nucleosidase (MTN) has three substrates MTA, SAH and 5'-deoxyadenosine (5'dADO). In each case, MTN cleaves the glycosidic linkage between the adenine ring and ribose sugar. MTN plays an essential part of methionine and purine salvage pathways, the activated methyl cycle, autoinducer-2 production, and radical S-adenosylmethionine (SAM) dependent reactions that are integral to vitamin synthesis. In this study, the impact of MTN activity on vitamin production and vitamin dependent metabolism were studied in E. coli strain O157:H7 wild type (WT) and MTN knock-out (KO) cells. Vitamins serve as cofactors for multiple pathways involved in bacterial metabolism. Proteomic studies comparing WT and KO strains have shown that the MTN KO strain expresses altered levels of enzymes involved in vitamin synthesis (thiamine, lipoate, biotin, etc.) and downstream enzymes that depend on these vitamins for activity. The results of our studies show that the activity of the biotin-containing enzyme acetyl-coA carboxylase (ACC) is reduced in the MTN KO strain. ACC is required for fatty acid biosynthesis. By biotin ELISA and western blot, we see a dramatic decrease in native biotinylation of ACC. Similarly, the activity of thiamine and lipoate dependent enzymes were also found to be reduced. We propose that loss of MTN activity leads to an accumulation of 5'dADO that in turn leads to product inhibition of radical SAM reactions, thus altering global metabolism through decreases in activity of vitamin dependent enzyme steps. Since MTN is only present in microbes, not humans, and central to metabolism, it may be a good target for antibiotic development. Our studies are useful in demonstrating potential mechanisms of action for such antibiotics.

Julie Ramirez
Faculty Mentor: Dr. Neil Carter, Department of Human Environment Systems

Research Title: Estimating Anthropogenic Influences on Species Occupancy at La Selva Biological Station, Costa Rica

The global network of nature reserves is intended to be refuges for wildlife species around the world. However, nature reserves are experiencing increasing amounts of human visitation each year, and it is critical to investigate how this influx in disturbance is influencing the space use, abundance, and richness of wildlife species in those reserves. We used camera trap data collected at La Selva Biological Station in Costa Rica, to understand how the presence of humans and other environmental factors are influencing the presence and distribution of various wildlife species. We deployed 9 cameras, in three blocks, on 9 different trails and accumulated 208 active camera nights in 2018. A total of 9,692 photos were obtained of 17 different animal species. We hypothesize that the occupancy rate of species will be primarily influenced by human presence on trails within the reserve. The most commonly detected species were Collared Peccaries (*Pecari tajacu*) with 0.837 average detections per day, Central American Agoutis (*Dasyprocta punctata*) with 0.409 average detections per day, and Great Curassows (*Crax rubra*) with 0.173 average detections per day across all camera sites. I will use the package "unmarked" in the program R to determine the influence of humans on species occupancy and richness.

Alex Schweitzer
Faculty Mentor: Dr. Dorsey Wanless, Department of Geosciences
Research Title: Formation of Lava Samples Collected by Three Alvin Submersible Dives at 14°N on the Mid-Atlantic Ridge

In 2018, a research cruise investigated the Mid-Atlantic Ridge at 14°N. During this expedition the seafloor was mapped using the AUV *Sentry* and basaltic lavas were collected using the HOV *Alvin*. To better understand the origin of these lavas, major element compositions of 40 basaltic glasses from three *Alvin* dives were measured using the BSU SXFive Electron Microprobe and trace element contents were measured on 33 samples using solution ICP-MS. Trace element ratios and patterns are important tools for investigating magmatic processes because they can be used to evaluate different magmatic processes; such as the amount of melting of the Earth's mantle that produces the magma and the extents of crystallization prior to eruption. Lavas collected on dives AL4953 and AL4954 have similar Rare Earth Element patterns, but variable elemental abundances, suggesting fractional crystallization was an important process in their formation. By contrast, lavas collected on dive AL4955 have variable trace element patterns and ratios, indicating a change in the extents of mantle melting. To further investigate the differences in these compositions, we will use numerical models to quantify the percent of mantle melting and extents of crystallization that led to the formation of lavas erupted in this region.

Joey Tuccinardi
Faculty Mentor: Dr. Don Warner, Department of Chemistry and Biochemistry
Research Title: Synthesis of Substituted Heterocycles to Inhibit a Pro-Metastatic Cytokine

While there have been significant advances in treatments for pre-metastatic breast cancer, the five-year survival rate post-metastasis remains an abysmal 27%. Systemic therapy continues to be the recommended course of treatment for patients diagnosed with metastatic breast cancer, but treatments that prevent distant metastases have yet to be discovered. Inflammatory cytokines (ICs) are small proteins involved in cell signaling that regulate inflammation and other important cellular processes. A certain IC binds to its main receptor to activate cell signaling pathways that are capable of promoting the invasive potential of cancer cells during the preliminary stages of the metastatic cascade. This has led to an interest in the development of small molecule inhibitors (SMIs) that bind to and inhibit the IC responsible. Previously, an enzyme-linked immunosorbent assay (ELISA) demonstrated that IC-SMI-10 inhibited the expression of pSTAT3 to a significant extent, indicative of competitive inhibition of the IC binding to its main receptor. Structurally, IC-SMI-10 contains a furan core appended with two benzodioxole groups at positions 4 and 5, a nitro group at position 3, and a phenyl hydrazone moiety at position 2. The aim of this research is to optimize inhibitory activity by systematically investigating the role of each component. Thus far, the furan core has been converted to a thiophene, an N-H pyrrole, an N-Me pyrrole, and an N-PMB pyrrole to assess the importance of the heterocycle. Also, to investigate the aryl groups, Suzuki coupling reactions have been used to incorporate 3,4-alkoxy or phenol, indole, benzodioxane, and other heteroaromatic groups. Lastly, substitution of the phenyl hydrazone moiety with a carboxylic acid, α,β-unsaturated acids, amides, amines, and other groups has sought to explore the importance of substitution at this site. Preliminary ELISA and ITC experiments confirm molecular docking experiments that suggested the nitro group was not an important contributor to inhibition, while the length of the side chain at position 2 is significantly important, as shorter, non-conjugated chains exhibit little to no binding to the IC. Similarly, CSP-NMR experiments suggest IC-SMI-10 analogs bind to the IC appreciably. These and other results will be reported.

Malyk Walker
Faculty Mentor: Dr. Daniel Fologea, Department of Physics
Research Title: Influence of Voltage Rate on the Diffusion of Organic Ions through Bilayer Lipid Membranes

Tetraphenylphosphonium chloride(TPP) and Sodium Tetraphenylborate(TPB) are organic ions that are able to passively move across the membrane down the electrochemical gradient. To further investigate the transport of organic ions through the lipid partition of a membrane, we employed artificial planar bilayer membrane bathed by electrolyte solutions. The bilayer membrane integrity was assessed from capacitance and conductance measurements. Changes in membrane permeability upon organic ion addition were monitored by recording the ionic currents in response to variable voltage ramps. Besides expected changes in membrane permeability we observed that the linearity of the I-V plots is strongly influenced by the rate of the voltage change. This is a good indication that the transmembrane transport is a diffusion limited process. In conclusion, these ions are good experimental models for helping us understand similar ionic transport processes through biological membranes.

Ariel Weltner
Faculty Mentor: Dr. Paul Simmonds, Department of Physics, and Micron School of Materials Science and Engineering
Research Title: Analyzing the Effect of Gold Reflective Coatings on GaAs Quantum Dot Photoluminescence

Molecular Beam Epitaxy (MBE) is a method for making high purity, tensile-strained GaAs quantum dots (QDs) embedded in solid-state semiconductors. QDs, excited by electricity or lasers, emit photons characteristic of the QDs size and composition, which may be used in tunable optoelectronic devices such as LEDs, lasers and solar cells. Understanding the light emission properties of these QDs is essential for these applications, as well as for continued QD research. Photoluminescence (PL) is a laser-excitation technique used to determine these properties.

Occasionally, the PL signals from our samples are too low in intensity to be accurately detected. We will investigate whether the addition of gold coatings on the back of QD samples improves PL emission by reflecting additional photons into the detector. To apply these reflective coatings, we first prepare the samples using a chemical wet etch process and then deposit thin gold films via physical vapor deposition. We will analyze the difference in PL intensity between coated and noncoated samples and gauge the influence of gold deposition thickness.

Donovan Wright
Faculty Mentor: Dr. Clare Fitzpatrick, Department of Mechanical & Biomedical Engineering
Research Title: Using a Convolutional Neural Network to Segment the Knee

For this project, I will develop an algorithm to segment the knee which consists of the femur, tibia, and patella bones and their respective connected cartilage. The algorithm is based a convolutional neural network (CNN) which will be fed two different data sets. The first data set consists of 26 MRI images of patients who had reoccurring patellar dislocation. The second data set is from the Osteoarthritis Initiative (OAI) dataset which consists of 20 more patients. This combined total of 46 patient's MRI images will be segmented into sagittal slices with each MRI consisting of around 130 sagittal slices giving a total of 5980 sagittal slices. This number of sagittal slices will fluctuate depending on the resolution of the MR images and the type of scanner used. Once a working model is developed, I will validate and test it on more of the Osteoarthritis Initiative data set which consists of 4,796 patients. The overall objective of this project was to efficiently segment subject-specific knee structures, and then to later develop a way of transforming these CNN generated segmentations into a 3D model. These models will ultimately be used for subject-specific finite element simulations to evaluate joint mechanics.

Higher Education Research Council
Undergraduate Research Supplemental Funding
Boise State University
Final Report

Academic Year 2018-19

Donna Llewellyn, Executive Director, Institute for STEM & Diversity Initiatives
Catherine Bates, Assistant Director, Institute for STEM & Diversity Initiatives


Introduction

The Institute for STEM & Diversity Initiatives oversaw the HERC Undergraduate Research Supplemental Funding at Boise State University Fall 2018, and Spring 2019. These funds were used for four purposes: (1) We supported five students from the College of Western Idaho to have a research experience, (2) Three Boise State students were offered research opportunities, (3) We funded travel for two Boise State students to attend professional research conferences, and (4) We brought Dr. Carrie Cameron from the University of Texas MD Anderson Cancer Center to the Boise State Campus.

For the CWI research opportunities, Associate Professor of Biology Dusty Perkins, and Physics Instructor Stephanie Sevigny at the College of Western Idaho (CWI) created an application form. All STEM department chairs and faculty at CWI were notified of the HERC Research Fellowship application, and the application was also shared directly with CWI students through email and the Math and Science Hub (MASH), a cross-disciplinary student and mentor community at CWI that supports academic engagement and success among CWI students through sharing resources and experiences in science, research and collaboration. Thirty-three students applied for the fellowship, from which five were selected for funding. All five of these HERC fellows from CWI presented at the Idaho Conference of Undergraduate Research at Boise State University in July.

For the Boise State research and travel opportunities, we used the same process as reported on in our standard HERC Undergraduate Research final report.

Dr. Cameron visited with Boise State faculty, students, and administrators on February 26th, 2019. She held a one hour Science Communication Strategies Discussion with students. She also hosted a two-hour Science Communication Workshop for Faculty. Her workshops, and informal meetings provided Boise State students and faculty, a suite of tools and strategies for helping strengthen student's science communication skills. Here were just a few statements from Dr. Cameron's survey evaluations:

> "Carrie was an excellent facilitator, allowing the audience to engage."
> "This was so wonderful (& necessary!) Thank you for bringing her to Boise State."
> " I gained a lot of resources and knowledge of where to find other resources in the future for promoting student's science communication skills."

On behalf of the Institute for STEM and Diversity Initiatives, we thank the Higher Education Research Council for their generous support in helping build meaningful learning experiences for Idaho students and supporting faculty professional development.

HERC Funding:

The Higher Education Research Council provided $32,000 in supplemental funding for STEM undergraduate research this year. Please see table below of how stipends and travel awards were dispersed.

Stipends	Amount
Boise State Research Stipends	$10,000
College of Western Idaho Research Stipends	$15,000
Student Travel to Professional Conference	**Amount**
2019 Seismological Society of America Annual Meeting (1 student)	$1, 635.97
2019 Pacific Sociological Association Conference (1 student)	$1,000
Professional Development Workshop	**Amount**
Dr. Carrie Cameron Workshop & Travel Expense	$3906.46
Summer Research Community	**Amount**
Summer Research Community Supplies	$457.57
Total	**$32,000**

College of Western Idaho Undergraduate Research Fellows and Discipline

Student Name	Gender	Ethnicity	Race	STEM Major
Mia Cinello-Smith	F	NonHispanic/Latino/a	Caucasian	Biology – Natural Resources
David Maldonado	M	Hispanic/Latino/a	Caucasian	Biomedical Engineering
Casey Robinson	F	NonHispanic/Latino/a	Caucasian	Biology – Natural Resources
Antony Tuss	M	NonHispanic/Latino/a	Caucasian	Electrical Engineering
Zack Szymczycha	M	NonHispanic/Latino/a	Caucasian	Biology – Natural Resources

Boise State Research Fellows Undergraduate Research Fellows and Discipline

Student Name	Gender	Ethnicity	Race	STEM Major
Kyle Kramer	M	NonHispanic/Latino/a	Caucasian	Electrical and Computer Engineering
Jessica Mueller	F	Hispanic/Latino/a	Caucasian	Geosciences
Samantha Schauer	F	NonHispanic/Latino/a	Caucasian	Mechanical Engineering

Travel Awards

Student Name	Gender	Ethnicity	Race	STEM Major
Nicole Clizzie	F	NonHispanic/Latino/a	Native American	Geosciences
Bryant Hey	M	NonHispanic/Latino/a	Caucasian	Sociology

Dr. Carrie Cameron Workshop Agenda:

Monday, February, 25th		
Time	Description	Location
3:58 PM	Arrive in Boise (Catherine Bates will pick you up from the airport)	
4:30 PM	Check in at hotel	
5:30 PM	Dinner with Donna Llewelyn, Executive Director for Institute for STEM & Diversity Initiatives, and Catherine Bates	ALAVITA, 807 W Idaho St, Boise, ID 83702
Tuesday, February 26th		
8:30 to 9:00 AM	Coffee at Starbucks, Albertsons Library, Boise State University	
9:00 to 10:00 AM	Meet with Program Directors/Coordinators • Dr. Amy Ulappa, Clinical Assistant Professor, NSF Gateway Scholars Coordinator • Barb Jibben, Program Manager at Biomolecular Research Center • Dr. Cheryl Jorcyk, Professor of Biological Sciences, Director,	Albertsons Library 201C

	Clinical/Translation Research • Gregory Martinez, Director of Center for Multicultural Education Opportunities	
10:30 to 11:30 AM	Science Communication Strategies Discussion with Students	Riverfront Hall, 301
11:30 to 1:00 PM	Lunch with Students • Julie Ramirez • Jacob Tenorio • Jessica Mueller Sandra Ambriz	Madre, 1034 S La Pointe St, Boise, ID 83706
1:00 to 2:30 PM	Meet & Greet with College of Health Science Faculty • Dr. Bob Wood, Director School of Allied Health Sciences • Dr. Cara Gallegos, Assistant Professor • Dr. Joelle Powers, Associate Dean of COHS, Professor • Ella Christiansen, Director COHS Office of Research Dr. Stephanie Hall, Clinical Assistant Professor	MBEEB Building, 2302
3:00 to 5:00 PM	Science Communication Workshop for Faculty	MBEEB Building, 2302
5:00 to 6:30 PM	Dinner and Networking	Papa Joe's, 1301 S Capitol Blvd, Boise, ID 83706
Wednesday, February 27		
6:25 AM	Depart Boise	

HERC Fellow CWI Student Abstracts:

Mia Cinello-Smith
Faculty Mentor: Dusty Perkins MS, Department of Biology, College of Western Idaho
Research Title: **Phenological Variation Among Western Populations of Showy Milkweed (*Asclepias speciosa*)**

Western monarch butterflies (*Danaus plexippus*) have declined ~97% from historic abundances in the early 1980s and are being evaluated for listing under the Endangered Species Act. Habitat loss and fragmentation in wintering, migratory, and breeding areas are considered key causes. Since monarchs depend on milkweeds (*Asclepias sp.)* for reproduction, there is increased interest among conservationists to plant milkweeds as habitat restoration. Showy milkweed (*Aslceipias speciosa)* is the most common and abundant milkweed species in the Western US. Successful habitat restoration will require germplasm that is adapted for target restoration environments and seasonal phenology. Phenological traits are adaptive, easily observable, and shaped by climate; making them helpful in genecological applications for determining seed transfer zones. We evaluated phenological variation among 35 showy milkweed populations from across the Intermountain West to determine geographic patterns of adaptive traits and their relationships to local climates using a common garden approach. We used remotely sensed climate data in conjunction with growth and reproductive phenology data to identify variation in adaptive traits and correlate them to elevation and climate variation. Here we present the results of our analyses and their implications for defining seed transfer zones for showy milkweed in the context of monarch butterfly conservation.

David Maldonado
Faculty Mentor: Dr. Kristen Mitchell, Department of Biological Sciences, Boise State University
Research Title: RNA-seq Reveals Extracellular Matrix Remodeling Processes Mediated by AhR Activation

Non-alcoholic fatty liver disease (NAFLD) refers to the accumulation of liver fat in the absence of alcohol consumption. NAFLD risk factors include obesity, type II diabetes, and hypertension. In about 30% of NAFLD patients, disease progression includes inflammation and advanced fibrosis, which necessitate liver transplantation. Liver fibrosis occurs when activated hepatic stellate cells deposit collagen throughout the liver. We previously established a role for aryl hydrocarbon receptor (AhR) signaling in regulating stellate cell activation. In this study, we determined how AhR activation impacts NAFLD development and its risk factors. C57Bl/6 mice were treated with 1.0 mg/kg carbon tetrachloride (CCl_4) twice a week for 5 weeks. During the final week, 100 μg/kg of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) was administered to elicit AhR activation. Histological analysis revealed that CCl_4/TCDD co-treatment produced advanced NAFLD, based on the presence of hepatic steatosis, fibrosis and inflammation. CCl_4/TCDD co-treatment also modulated the hepatic expression of genes related to type II diabetes. Treatment with CCl_4 or TCDD alone failed to elicit NAFLD and had no impact on diabetes-related gene expression. We conclude that AhR activation may advance NAFLD progression by exacerbating liver injury and/or by increasing the development of risk factors (e.g. type II diabetes) associated with NAFLD progression.

Casey Robinson

Faculty Mentor: Dusty Perkins MS, Department of Biology, College of Western Idaho
Research Title: Variation in Adaptive Traits and Seed Zone Evaluation of Showy Milkweed (*Asclepias speciosa*)

Monarch butterfly (*Danuas plexippus*) populations are imperiled and in review for listing under the Endangered Species Act. Among many contributors to the decline is the loss of breeding, migratory, and overwintering habitat. Showy milkweed (*Asclepias speciosa*) and other obligate milkweeds are essential for monarch reproduction and have thus been cornerstones of monarch habitat restoration efforts in the Intermountain West. However, many potential restoration areas lack convenient seed sources to supply prospective efforts. Furthermore, because certain populations may be better adapted to specific local climates and selective pressures, the introduction of non-native, poorly adaptive genotypes may have negative consequences for restoration efforts and milkweed-dependent species. We used a genecological approach to identify adaptive traits among 35 showy milkweed populations from the Intermountain West to inform seed transfer zones for *A. speciosa.* We used morphological measures and plant growth data in conjunction with remotely sensed climate data to identify putative adaptive traits and determine how they relate to local climate variation. Here we present the results of our analyses and their implications for classifying showy milkweed seed transfer zones and maximizing restoration and conservation benefit for monarch butterflies.

Zack Szymczycha
Faculty Mentor: Dr. Sara Schulwitz, Director of the American Kestrel Partnership, The Peregrine Fund
Research Title: A Methodology for Systematic Mapping in Raptor Biology

Knowledge from peer-reviewed research in raptor biology is based primarily on a small handful of raptor species, while a large portion are virtually unstudied or understudied. With over 500 raptor species globally, this limited knowledge base is a chief impediment to conservation efforts. Here we introduce a systematic mapping protocol for raptor species that expedites the literature review process to better inform stakeholders of the current species-specific research. Using the RepOrting standards for Systematic Evidence Syntheses (ROSES) protocol guidelines, we constructed a methodology for systematic information mapping for raptor conservation that encompasses: stakeholder engagement; objective of the review; methods; searches; screening and inclusion criteria; critical appraisal; data extraction; data synthesis and presentation; and declarations. This method provides a comprehensive synthesis of objective evidence that features repeatable standards for information extraction that will ultimately contribute to a centralized raptor conservation database. Initial efforts involving the California condor (*Gymnogyps californianus*) as a conceptual model to demonstrate the methodology has identified 255 literature items of which 165 were extracted as PDFs, while the screening process remains ongoing.

Anthony Tuss
Faculty Mentor: Dr. Kurtis Cantley, Department of Electrical and Computer Engineering, Boise State University

Research Title: Advancements of Dielectrics and their Effects on Stabilizing the Electrical Grid
The modern world is more dependent on it's power than ever before, so much so that the stabilization of the electrical grid is of utmost importance. Thermal stresses, such as geomagnetic disturbance and running the grid transformers at a higher temperature are major concerns. The Idaho National Laboratory has subcontracted Boise State University to test and analyze data on

developed dielectric materials in the hopes that it will prove to be more reliable. The data that will be gathered includes, but is not limited to: resistivity, dielectric constant, breakdown voltage, and electrical reliability under heat stressors of the material.

HERC Fellow Boise State Student Abstracts:

Kyle Kramer
Faculty Mentor: Dr. Harish Subbaraman, Department of Electrical and Computer Engineering, Boise State University
Research Title: Understanding the Effects of Plasma Parameters on Plasma-Jet Printed Material Films

The demand for consistent additive manufacturing processes for biosensors that make use of flexible substrates is increasingly desired. Recent work has demonstrated a strong candidate for such processing is a plasma jet printing process. Optimization of the plasma jet printing process requires investigating the effects of different plasma conditions and flow rates, nanomaterial inks, and substrates on print quality and material properties. In this work, we examine the effects of using argon and nitrogen plasma sources on the conductivity and adhesion of four-point structures printed on polyamide substrates. The plasma source is a parallel plate discharge with a 0.5-1mm gap using two embedded metal electrodes. The source operates at 20 kHz and 2-3.5 kV. A new plasma source enclosure and mounting fixtures have been combined with an XY stage to print the inks. Print quality is verified through imaging the samples via scanning electron microscopy and examining the atomic spectra. Our future work involves the characterization of other nanoparticle inks and further demonstrating plasma jet printing as a cost effective, time efficient, and viable process. These results will be presented.
*This research is supported by a seed grant from the NASA Idaho Space Grant Consortium (ISGC).

Jessica Mueller
Faculty Mentor: Dr. Vicken Hillis, Department of Human Environment Systems, Boise State University
Research Title: Implications of Grazing Usage over Time and Space in the Thunder Basin Ecoregion
National grasslands are public lands that have diverse and critical uses. They serve as wildlife habitat, contain mineral resources, and are used recreationally. The Thunder Basin National Grassland, located in the Powder River Basin of Wyoming, spans more than 500,000 acres and local ranchers rely on that acreage to feed their cattle. Effective management of these grazing lands is challenging because agency managers have to balance multiple private and public objectives. Advancing rangeland policy requires an accurate understanding of previous grazing history. Even so, few long-term, quantitative records of grazing intensity on this land exist. To address this gap, we digitized physical records of four decades of grazing usage. We analyzed this data to examine variation in grazing intensity over time and space. We found that there was a steady increase in grazing intensity over time, but it fell dramatically in the early 2000s. This is an important observation that can help government agencies understand how various social and environmental factors impact grazing intensity. Application of this understanding can help create sustainable grassland policies.

Samantha Schauer

Faculty Mentor: Dr. Krishna Pakala, Department of Mechanical & Biomedical Engineering, Boise State University
Research Title: Living Learning Communities and Their Impact on First Year Engineering College Students
Office hours that happen in a virtual environment are called virtual office hours. A virtual environment can provide students and faculty with more flexibility in meeting times and locations, content delivery, and types of interaction. This type of student-faculty interaction can be easily hosted from a faculty computer/mobile device/tablet. With an invitation, students can login to the online session and join their instructor and peers in a virtual space. Using mobile technologies, students can join virtual office hours from a variety of locations including, the library, outdoors, on the commute ride home, while caring for children, eating dinner, and even while grocery shopping. Virtual office hours allow for more flexibility of student-faculty interaction. They are an alternative to traditional office hours. This type of student-faculty interaction helps increase students' trust in their teacher's care of their learning. This presentation describes the design and implementation of virtual office hours for courses in the thermal-fluid sciences (Thermodynamics, Fluid Mechanics and Heat Transfer). It also reports on students' learning experiences.

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

August 29, 2019

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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 tasked with taking the lead in enabling research opportunities for undergraduates at the U of I. Among its roles, it manages various competitive student grant programs that directly support student research.

During FY2019, generous funding from the State Board of Education permitted the U of I to continue its Summer Undergraduate Research Fellowship (SURF) Program. This intensive 10-week summer research experience actively engages undergraduates in faculty-mentored, independent research. 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 $1,000 to help offset materials and supplies and other project-related expenses. 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 16 SURF awards during the summer of 2019.

Funding provided by the State Board of Education also allowed the Office of Undergraduate Research to support a number of undergraduate researchers during the academic year. This was accomplished through competitive Undergraduate Research Grants awarded to students during the spring semester of 2019. 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. State Board of Education funding supported 7 Undergraduate Research Grants during the spring semester of 2019.

Almost all of the U of I students supported by State Board of Education funds attended and presented the results of their projects at the Idaho Conference on Undergraduate Research (ICUR) held in Boise in July of 2019. Several of our students also presented posters of their work at the U of I Undergraduate Research Symposium in April 2019. Additionally, some presented their work at national conferences. A few of students were unable to attend this year's ICUR conference. In lieu of this, these students will be required to present their results at the U of I Undergraduate Research Symposium in April 2020.

The funding provided by the Idaho State Board of Education was in the form of two separate awards to the University of Idaho. These awards were managed by the U of I Office of Undergraduate Research and the awards were used together to help fund its competitive student grants program. This final project report combines all of the student project reports funded by both SBoE awards into a single document.

Collectively, the awards provided by the State Board of Education helped fund 23 student research projects. In a few cases, individual projects ended up coming in slightly under the $1,000 amount allotted for project-related expenses. Additionally, one student's summer project played out differently than planned and although he was able to complete the work, his project-related expenses will not come into effect until later in the fall of 2019. Consequently, he spent very little of the project money awarded to him. Taken together, these outcomes left us with a small amount unexpended funds at the close of FY2019. These funds were returned to the State Board of Education.

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.

Final Project Report: Office of Undergraduate Research (OUR) Spring Undergraduate Research Grant - Spring 2019

Grant Recipient: Chloe Beall, Wildlife Resources, University of Idaho

Faculty Mentor: Dr. Lisette Waits, Professor and Chair, Department of Fish & Wildlife Sciences

Project Title: Columbia Basin Pygmy Rabbit Winter Field Sampling and Genetic Monitoring

Abstract: The pygmy rabbit (*Brachylagus idahoensis*) population in central Washington, United States, has declined significantly in response to habitat loss and fragmentation. The goal of my research was to assist the Washington Department of Fish and Wildlife (WDFW) in determining the number of active burrow sites in the sampling area, collecting fecal samples, and performing genetic analyses on the samples. This research is a continuation of the recovery program overseen by WDFW and will provide insight into population estimation methods using burrow numbers. My research seeks to answer the following questions: How many burrows are detected in the focal sampling area? How many pygmy rabbits are identified from fecal pellets collected in this area? What is the ratio between the number of rabbits detected and the number of active burrows detected? We performed transect searches to locate active burrows and collected fecal samples for genetic analysis across a 3.4 km2 region of the reintroduction area. Individual identification was determined using genotypes from 6-10 microsatellite loci. We collected samples from 103 new wild born individuals, representing 150 unique locations. Overall, we identified individuals from 150 active burrow sites. This resulted in an average of 0.687 rabbits per burrow in the ECRP site.

Project Accomplishments

1. *Determined the number of burrows in the sampling areas*
   Result: With the help of many volunteers, I was able to determine the number of burrows in my primary East Conservation Reserve Program Field (ECRP)study site in central Washington. We walked along belt transects for thorough burrow detection. We collected 271 fecal samples at burrows for genetic monitoring and positively identified 204 of those samples as pygmy rabbit samples. I was also able to compare these results with results from previous work in another study site in the Chester Butte area. The Chester Butte sample was smaller, with 14 burrows and 6 pygmy rabbit individuals detected, but it provided a potentially useful baseline for my study.

2. *Identified individual pygmy rabbits from the sampling areas using genetic analysis*
   Result: After collecting fecal samples from all the detected burrow sites and eliminating samples that were identified as other rabbit species using mitochondrial DNA, pellets underwent further genetic analysis utilizing 19 nuclear DNA microsatellite loci including one sex ID marker. Of the 204 pygmy rabbit fecal samples, 153 passed the M2 multiplex requirements. From those samples, we identified 103 new wild born individuals.

3. *Determined a possible ratio between number of burrows and number of pygmy rabbits in the sampling area*
   Result: Of the 103 individuals identified, 80 were identified at only a single location. The remaining 23 were detected at 70 locations collectively. Based on these data, it seems that there is an average ratio of 0.687 rabbits per burrow. Furthermore, the data from the Chester Butte site

resulted in an average of 0.429 rabbits per burrow. However, given the number of rabbits that were detected at only one location, this average likely has a large amount of variance.

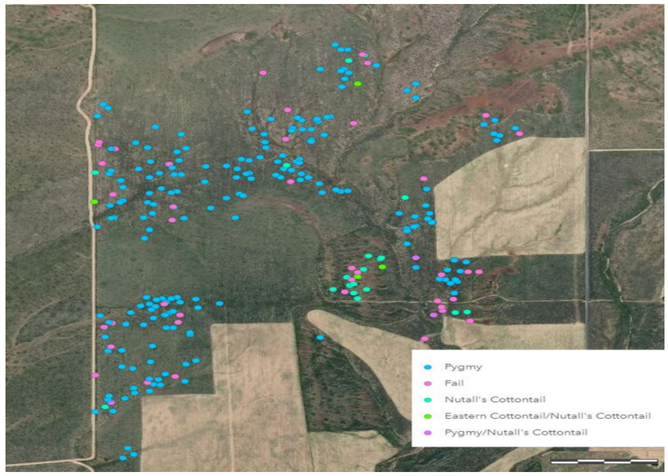


Figure 1. Map of sample locations from winter monitoring and species identification from CRP study area (204 Pygmy Rabbit samples, 20 Nutall's Cottontail, 4 Eastern/Nuttall's mixed, 3 Pygmy/Nutall's mixed, 42 failed).

Summary of Budget Expenditures

Item	**Cost**	**Explanation**
DNA extraction supplies	900	150 samples x $6 sample
Posters	100	For UI UG Research Symposium and ICUR
Total	**1000**	

Conference Presentations: I presented a poster of my work at both the Undergraduate Research Symposium at the University of Idaho in April 2019 as well as the Idaho Conference on Undergraduate Research (ICUR) in Boise in July 2019.

Acknowledgement: I greatly appreciate the generous support provided to me by the Idaho State Board of Education HERC in the form of an Undergraduate Research Grant from the U of I Office of Undergraduate Research. This grant funded the genetic analysis needed for the success of my project. I am also grateful to both my faculty mentor Lisette Waits and my graduate student mentor Stacey Nerkowski for all of their help along the way.

Final Project Report: Office of Undergraduate Research (OUR) Spring Undergraduate Research Grant - Spring 2019

Grant Recipient: Mallory Cullen, University of Idaho

Faculty Mentor: Dr. Joe Kuhl, Associate Professor, Department of Plant Sciences, University of Idaho

Project Title: Role of litchi tomato peroxidases in potato cyst nematode immunity

Abstract: Potato cyst nematodes (PCN) are obligate, biotrophic pathogens that are among the most damaging pests to potatoes. These nematodes can cause up to 80% yield loss and with soil fumigants becoming more restricted new strategies must be devised to deal with the infestation of this pest. Mechanical damage caused by pests resulting in a rapid oxidative burst and an upregulation of the peroxidase genes strongly implicate peroxidases in plant defense and immune response. Research conducted in *Solanum sisymbriifolium* (a plant resistant to PCN and a wild *Solanum* relative to potato) showed eleven peroxidase candidate genes are differentially expressed in infected versus uninfected roots, ten peroxidases were upregulated, and one was suppressed. In this project eight of these peroxidase gene candidates were amplified and the open reading frames for these genes cloned into a vector. The clones were submitted for sequencing and the resulting DNA sequences were analyzed. With the sequences for the open reading frames determined, the cloned peroxidases are ready to be placed into a suitable plant expression vector. Future research will be conducted to transform these peroxidase genes into susceptible potatoes to see if they confer resistance to PCN.

Project Summary and Accomplishments:
The goal of this project was to confirm peroxidase open reading frames, ORFs, that were differentially expressed in litchi tomato plants that were infected with potato cyst nematodes versus uninfected litchi tomato plants at the bench. RNA seq data showed 10 peroxidase candidate genes that could be linked with potato cyst nematode infection. Using these candidate open reading frames, primers were designed to amplify the fragments from cDNA. Once amplified, the fragments were cloned into the vector PENTR D-TOPO. From this vector, the plasmids were extracted and sent for sequencing. Using the sequencing results, the data was aligned to the reference sequences from the RNA seq data and analyzed for discrepancies. Due to some unforeseen complications, the confirmed sequence could not be directly integrated into PearleyGate 100 and introduced into agrobacterium. The construct was ligated into PearleyGate100 and transformed into JM109 cells. Using this construct, the plasmid was confirmed using sequencing. Once sequence conformation was complete, the plasmid was transformed into electrocompetent agrobacterium using electroporation.

A significant portion of this project was accomplished during the period of this grant. Starting with 10 predicted peroxidase open reading frames, 9 of them were able to be amplified using PCR and were of the correct size. One open reading frame, c10137/f1p4/96**,** did not match the predicted size of the fragment and did not proceed in the experiment. Next the amplified open reading frames were cloned into a PENTR vector. 8 of the ORFs were successfully cloned into the vector. One ORF, c90433/f240p109/1282, did not successfully clone and was therefore dropped at this stage. Once cloned, the plasmids were sent for sequencing. 6 of the ORFs had matching sequences to the reference sequence. c7557/f1p0/1301 and c6814/f2p4/1378 had 3 and 1 base pair changes respectively. All of these sequences are stored as glycerol stocks awaiting ligation into the PearleyGate 100 vector and then transformation into Agrobacterium. Some trouble was encountered with the ligation and transformation into agrobacterium process. The vector could not be confirmed in agrobacterium. To circumvent this process, the construct is now confirmed in JM109 cells and then extracted, sequence confirmed and transformed into agrobacterium. Only one peroxidase open reading frame, c16456/f1p3/1223, has been successfully ligated into PearleyGate 100 and transformed into agrobacterium. The next step of this project will be to get the remaining 7 peroxidase ORFs into PearleyGate100 and transformed into Agrobacterium. After this, the construct will need to be introduced into potato plants and genotypic and phenotypic analysis conducted.

For the budget, the money was dispersed amongst portions of my project. The first item purchased was NotI-Hf enzyme for $72.00. This enzyme was purchased to use during restriction digestions for conformation in the pENTR vector. $327.00 went towards purchasing a 100bp and ultra-low DNA ladder for use in gel electrophoresis when running the PRC and digested products. A total of $354.64 was used for sequencing of samples by Genewiz. This amount can be broken down by two rounds of sequencing for $174.00 and $162.00 along with shipping which was $9.32 each time. $180.00 was spent on Timentin, a compound needed to grow the transformed agrobacterium. Finally, the poster for the poster presentation was purchased for $48.00. **TOTAL: $1,000.28**

Conference Presentation: This research was presented at the 2019 UI Undergraduate Research Symposium and at the 2019 Idaho Conference on Undergraduate Research in Boise, ID.

Acknowledgment: This research could not have been as successful as it has been without the generous support of the Idaho State Board of Education/HERC. I truly appreciate the support given to me in the form of a U of I Office of Undergraduate Research Grant.

Final Project Report: Office of Undergraduate Research (OUR) Spring Undergraduate Research Grant - Spring 2019

Grant Recipient: Ren Dimico, Biological Sciences, University of Idaho

Faculty Mentor: Dr. Peter Fuerst, Associate Professor, Department of Biological Sciences

Project Title: Unravelling Genetic Determinants of Synapse Formation in the Mammalian Visual System

Abstract:

Blinding diseases, such as age-macular degeneration and glaucoma, are common causes of vision loss and occur in 2-15% of the population. A detailed understanding of visual system organization is a limiting factor in developing treatments for such disorders. Genetic blinding diseases are studied to understand visual system organization and diseases. Stationary night blindness, is caused by mutation in the *Dscaml1* gene. *Dscaml1* encodes for the protein, Down Syndrome Cell Adhesion Molecule-like 1 (DSCAML1), which plays a role in organization of cells critical for night vision. In a previous study we used electron micrographs to visualize the cellular organization of rod bipolar cells (RBC) in the synaptic pathway within the mouse retina, an accessible model for human diseases. We found an increased number of dendrite terminals that do not contact rod photoreceptors in the absence of DSCAML1. This project focuses on using immunohistochemical (IHC) techniques to compare the development of the synaptic pathway at multiple post-natal time points in three genotypes. It is predicted that the loss of DSCAML1 results in termination of the pathway between the RBC and dendrites instead of a delay in formation. This study is intended to guide clinicians seeking interventions for people with similar disorders.

Project Description:
The aim of this project was to optimize and utilize an IHC staining protocol to stain cryostat sectioned retinas for RBCs, puncta, and rods. First optimal concentrations and staining times were determined with the antibodies used. After obtaining an optimized protocol the ratio of puncta to RBCs was calculated using florescent imaging to determine if there is a delay in synaptic formation as the mouse ages throughout different timepoints. Three genotypes are being used in this study: B6 (wild-type), DSCAML1$^{+/-}$, and DSCAML1$^{+/+}$.

Summary of Project Accomplishments:
Optimal staining concentrations, times, and temperatures were determined in order to derive an optimized protocol for this study. All age points that were taken for study, within the three different genotypes, were successfully stained, counted and analyzed. Limitations were presented at the end of the summer due to working with specific timepoints of mice, but all mice that were taken for this study were analyzed up until this point.

Conference Presentations: I presented a poster of my work at ICUR in Boise in July 2019 as well as at the UI Undergraduate Research Symposium in April 2019.

Summary of Budget Expenditures:
New antibodies to stain the RBCs and puncta were ordered ($685). Part of the budget was also used for care of the animals used in this study ($245) in addition to poster printing ($70) for the ICUR conference I attended at the end of July. TOTAL EXPENDITURES: $1,000.

*This project will continue into the Fall 2019 semester as more mice can be taken for study at the desired timepoints.

Acknowledgement: I am very thankful for the generous support provided to me by the Idaho State Board of Education/HERC in the form of an Undergraduate Research Grant. I am also grateful to the U of I Undergraduate Research for all of its support and for making this grant possible.

Final Project Report: Office of Undergraduate Research (OUR) Undergraduate Research Grant - Spring 2019

Grant Recipient: Jadzia Graves, Materials Science and Engineering, University of Idaho

Faculty Mentor: Dr. Indrajit Charit, Department of Chemical and Materials Engineering

Project Title: Microstructural and Mechanical Properties Evaluation of Friction Stir Welded High Entropy Alloys

Abstract: Traditional alloys that are commercially available have one base element and trace amounts of multiple other elements. That limits the capabilities of the alloys as they are largely dependent on the base element instead of utilizing the abilities of all the elements in the alloy. High entropy alloys (HEAs) are an advancement of traditional alloys as they have a larger percentage of multiple elements. In this proposal, we will work on the effect of friction stir welding (FSW) to determine how it affects the microstructures and the correlating mechanical properties.

Project Overview: In this project, the High Entropy Alloy (HEA), known as $Fe_{42}Mn_{18}Co_{10}Cr_{15}Si_5$, was looked at under various microscopes to see how Friction Stir Welding (FSW) affects the mechanical properties of the material. FSW is when a rotating tool heats and joins two side by side plates. It is important to know how the material is affected by this process to understand how the material changes as it undergoes this process.

Project Accomplishments:

1. Learned how to prepare samples for various forms of testing and microscopy

To prepare samples for the optical microscope, a small section was cut off of the main block. It was placed into a mold to create a cylindrical object with a 1in diameter and a thickness of .5in. The sample was then grinded with sandpaper from 120 grit to 1200 grit before it was polished with a diamond slurry. In order to see the microstructures it was lightly etched with a hydrochloric/nitric acid solution. After the samples were looked at with the optical microscope, they were also used on the Vickers Hardness machine.

For the scanning electron microscope (SEM), the sample was prepared in much of the same manner, but the alloy had to be extracted from the mold. This is to allow the electrons to properly bounce off of the alloy which is what provides the images.

Transmission electron microscope (TEM) samples are prepared slightly different. Rather than being placed in a mold, a thin sliver of the material is glued onto a metal disc. Once one side has been polished, the sample is removed and reattached on the other side. As the second side is being polished, it is also measured to ensure that the sample is less than 100 micrometers thick.

The Instron testing machine requires samples to be cylindrical, so the material was machined to the proper size.

2. Used the optical microscope, the scanning electron microscope (SEM), Vickers Hardness machine, and the Instron testing machine

The optical microscope is used to see basic microstructures. Typically, images are taken at magnifications from 50x to 100x, but can go as high as 500x. Multiple images were taken across the weld zone, so in the future a single image of the weld zone will be available.

SEM is used to look more in depth at the microstructures. The magnifications go up above 2000x. To use the SEM, the sample was loaded into a vacuum chamber. Cameras were used to position the sample under the electron beam.

The Vickers Hardness machine is used to determine the hardness of the material. This is done by pressing a diamond tip into the material and measuring the imprint. For this material, measurements were taken across the weld zone to see how the weld affects the hardness.

The Instron testing machine has many functions, for this project, compression tests were performed. From the compression test, mechanical properties such as Young's modulus and ultimate yield strength could be determined. Compression tests were chosen over tensile tests do the amount of material that was saved by doing compression, along with the fact that the microstructures can be analyzed after compression tests but not tensile tests.

Summary of Budget Expenditures:

Description	**Title**	**Cost**
0319 WSU PULLMAN 509-335-9651 WA	Analytical Services	**200.67**
Boise State University	Analytical Services	**187**
Supplies 04252019	Research Supplies	**612.33**
	Total	**1000**

Conference Presentations: I presented images taken from this project at the UI Materials Advantage Paper Night hosted by ASM International in April 2019. I presented a poster of my work at ICUR in Boise in July 2019.

Acknowledgements: I sincerely thank the State Board of Education for their support in the form of an Undergraduate Research Grant from the Office of Undergraduate Research at the University of Idaho. I would also like to acknowledge Franceshi Microscopy and Imaging Center at Washington State University for the use of their Transmission Electron Microscope.

Final Project Report: Office of Undergraduate Research (OUR) Spring Research Grant – Spring 2019

Grant Recipient: Reagan Haney, College of Agricultural and Life Sciences, University of Idaho

Faculty Mentor: Shirley Luckhart, Professor, Department of Entomology, Plant Pathology, and Nematology; Professor, Department of Biological Sciences

Project Title: Effects of Abscisic Acid (ABA) on *Anopheles stephensi* Reproduction

Abstract Hundreds of millions of malaria cases are reported every year despite significant global efforts focused on elimination. Accordingly, new vaccines, therapeutics, and strategies for vector control are needed to support these efforts. *Anopheles stephensi* is an aggressive malaria vector mosquito that has invaded and become established in Sri Lanka, Djibouti and Ethiopia, with significant risk for range expansion into Somalia, Eritrea and Sudan. In Djibouti, *A. stephensi* has been linked to a resurgence of severe infection with the human malaria parasite *Plasmodium falciparum*. Malaria control directed at reducing mosquito reproduction or fecundity is an important strategy, particularly for *A. stephensi* that is adapted to oviposition in artificial water sources in urban habitats. Mosquitoes consume blood to produce eggs. Following blood consumption, the protein Vitellogenin (Vg) is synthesized in the fat body of the female mosquito and transferred to developing eggs. Vg synthesis is stimulated following the blood meal by increasing titers of the hormone 20-hydroxyecdysone (20E). We have discovered that abscisic acid (ABA), a natural compound, can reduce mosquito fecundity. Based on studies in the flesh fly that showed that ABA can reduce Vg levels in this insect, we hypothesized that ABA reduces *A. stephensi* fecundity by reducing levels of Vg in the mosquito.

Project Description In 2016, there were 216 million reported cases of malaria worldwide and about half a million deaths occurred due to the devasting effects of the malaria parasite. Malaria is a vector-borne disease that is caused by a parasite, most commonly *Plasmodium falciparum*, transmitted through the bite of an *Anopheles* mosquito. There has been progression towards eliminating malaria in some areas of the world. However, there are still many challenges to overcome before eliminating malaria. Obstacles such as parasite resistance to antimalarial drugs and mosquito resistance to insecticides are just a few examples of obstacles that have yet to be tackled.

Project Accomplishments

1. Previous work in the Luckhart lab demonstrated that supplementation of adult female *A. stephensi* with ABA had no effect on egg production in the first reproductive or gonotrophic cycle. Given that female mosquitoes with access to blood can lay eggs approximately every 3-4 days and, thereby, complete multiple gonotrophic cycles during a complete lifespan, I determined whether supplementation of ABA to adult female mosquitoes could alter fecundity beyond the first gonotrophic cycle.

    Result: In the first set of experiments, adult female *A. stephensi* were supplemented with ABA and clutch size (number of eggs laid per female during one reproductive or gonotrophic cycle) was evaluated. I observed that ABA does not affect clutch size when supplemented to adult female mosquitoes.

2. Current research in the Luckhart lab has demonstrated that supplementation of ABA in water to mosquito larvae shortened time to pupation and body size of adult mosquitoes. Therefore, I tested

whether supplementation of ABA to mosquito larvae could alter reproduction of adult females derived from supplemented and control larvae.

Results: I observed that female *A. stephensi* derived from ABA treated larvae exhibited a significant reduction in clutch size relative to adult females derived from untreated larvae. These data indicate that ABA treatment of larvae results in physiological changes that persist into the adult stage and that are durable over time. It was also notable that ABA supplementation of *A. stephensi* larvae significantly reduced the lifespan of adult female mosquitoes derived from treated larvae relative to adult females derived from untreated larvae.

3. Based on our data, we hypothesized that ABA reduces *A. stephensi* fecundity by reducing levels of Vg in the mosquito.

   Results: 20E and Vg levels were evaluated post blood meal. Adult female *A. stephensi* in the control group exhibited the expected pattern of increasing 20E titer following a blood meal. Female mosquitoes derived from larvae treated with 1µM ABA and 100µM ABA group did not show the typical peak of 20E at 24 hr, indicating they did not properly respond to the blood meal. Further, adult female *A. stephensi* derived from larvae treated with 1µM ABA and 100µM ABA had increased Vg mRNA levels at 12 hr post blood meal relative to control, but reduced levels in the following 36 hr. This early increase in Vg mRNA expression followed by reduced Vg expression could explain why egg production was reduced but not blocked in adult females derived from larvae treated with ABA.

Conference Presentation: This study was presented as a poster at the University of Idaho Undergraduate Research Symposium in April 2019 and ICUR in Boise, ID, in July 2019.

Summary of Budget Expenditures

Item Purchased	Cost	Balance Remaining	Receive date
Caisson ABA	$641.91	$358.09	2/7/2019
IBB Blood	$300.00	$58.09	2/10/2019
Fisher Cotton Balls	$58.09	- 0 -	3/18/2019

Acknowledgment: I greatly appreciate the generous support provided by the State Board of Education in the form of a Spring Undergraduate Research Grant from the UI Office of Undergraduate Research. This was an amazing experience for me. Without this support from the SBOE/HERC, I would not have been able to participate in this research.

Final Project Report: Office of Undergraduate Research Grant - Spring 2019

Grant Recipient: Jordan Howard, Food & Nutrition, University of Idaho

Faculty Mentor: Katie Brown Ph.D., formerly Associate Professor, Department of Family & Consumer Sciences (Dr. Brown now works at Utah State University)

Project Title: Low Energy Availability and Bone Density in Non-Athlete Males at the University of Idaho

Abstract: Low energy availability (LEA) is a condition resulting from an insufficient amount of energy required for normal function and metabolic processes after accounting for exercise. Collegiate athletes are prone to developing LEA due to insufficient energy intake, and LEA is associated with decreased bone mineral density (BMD) in competitive athletes. However, little is known about the occurrence of LEA or its relation to BMD in non-athlete populations. This study aimed to investigate the prevalence of LEA and its relation to BMD in non-athlete males at the University of Idaho. Non-athlete males (n=21) ages 18-26 took part in this study. EA was assessed using measurements of dietary energy intake (DI), exercise energy expenditure (ExEE), and body composition. BMD was assessed using dual-energy x-ray absorptiometry (DEXA). Five participants (23.8%) identified with LEA based on an EA of < 30 kcal/kg of LBM/day. There was no correlation between EA and total BMD ($p = 0.951$), spine BMD ($p = 0.641$), or hip BMD ($p = 0.786$). However, total BMD was significantly correlated with body weight ($p < 0.001$). These findings differ from previous research among competitive athletes which found associations between LEA and BMD.

Project Accomplishments:

1. Assess the prevalence of low energy availability among non-NCAA athlete male students at the University of Idaho.

I was successful in assessing the prevalence of low energy availability among this population. I was able to measure this prevalence by monitoring participants' physical activity and dietary intake over a period of three days. Participants wore accelerometers to monitor their physical activity and tracked their diet using ASA 24, on online dietary assessment tool. 21 non-NCAA athlete males at the University of Idaho successfully completed this study. Among these participants, 71% (n=20) were found to have reduced energy availability while 23% (n=5) were found to have low energy availability.

2. Study the relationship between low energy availability and bone density in non-NCAA athlete males.

By using dual-energy x-ray absorptiometry (DEXA) technology, I was able to assess bone mineral density in participants. A comparison between bone mineral density z-scores and energy availability using Spearman correlations revealed there was no correlation between low energy availability and bone density ($p = 0.951$). However, a strong correlation was found between bone mineral density and body weight ($p = 0.001$).

3. Study the relationship between low energy availability and testosterone levels in non-athlete males.

A goal of this study was to test the following hypothesis: Testosterone levels in non-NCAA athlete college males with low energy availability will be significantly lower than males without low energy availability. Salivary testosterone samples were successfully obtained from participants who completed the study. These samples were sent to Salimetrics® to be analyzed. However, I have not yet received these results back from the company. Once these are received, I will be able to study the relationship between energy availability and testosterone in non-NCAA athlete males and test this hypothesis.

Summary of Budget Expenditures:

Supplies	**Cost**
Salimetrics® Testosterone Sampling Kits	**$900**
Participant Incentive	**$100**
Total:	**$1000**

Additional Information:
This project was originally titled, "Low Energy Availability and its Relation to Testosterone Levels in Non-Athlete Males." However, because the results of the testosterone sampling were not ready in time to present at the University of Idaho Undergraduate Research Symposium in April, I included the study of bone density in my project. Due to delays in the processing of testosterone samples, I have not yet received these results. When these results are analyzed, I plan to update this report with my new findings.

Conference Presentation:
This study was presented as a poster at the University of Idaho Undergraduate Research Symposium in April 2019 and ICUR in Boise, ID, in July 2019.

Acknowledgement:
I truly appreciate the generous support provided by the State Board of Education in the form of this undergraduate research grant. This was an incredible experience which greatly enhanced my education at the University of Idaho. This grant enabled me to participate in research on a level that otherwise would not have been possible. I learned a tremendous amount about research design, protocols, and techniques related to nutrition, as well as how to properly analyze and disseminate results. Thank you again for your generosity.

Special thanks to my faculty mentor Dr. Katie Brown, Eric Vallin, Krista Story, Megan Follett, and Dr. Ann Brown for their tremendous support and help with this project.

Final Project Report: Office of Undergraduate Research, Spring 2019

Recipient: Paul Riebe, Materials/Mechanical Engineering, University of Idaho

Faculty Mentor: Dr. Mark Roll, Associate Professor, Department of Materials Engineering

Project Title: ABS Microstructures in Extrusion 3D Printed Samples

Abstract: ABS plastic exhibits an interesting set of properties, making it ideal for certain applications. It is a convenient material for use in consumer grade additive manufacturing, and its cost is relatively low. This makes it popular for use as a filament in 3D printers like the Makerbot. However, parts printed out of ABS do not behave the same way as parts produced using traditional methods, like injection molding. Preliminary research done previously on the project shows that the failure patterns of ASTM dogbone testing samples are radically different when comparing layered prints and injection moldings. During tensile tests, printed samples fail suddenly, with little to no necking at the failure point. Injection molded samples follow a typical stress/strain curve. It would seem that there is something happening at a microstructural level to explain this phenomenon. The purpose of this research was to pinpoint this microstructural difference by extruding custom filament from the exact same ABS stock that was used to injection mold the sister samples. By eliminating any material differences between stock suppliers, the microstructural differences, it was hoped, would become apparent.

Project Accomplishments

1. First, the old research had to be compiled and organized. The project had been worked on by two students previously, and the records were both old and slightly disorganized. Some samples had been tested, but test sample lengths after tensile testing were never recorded.
   1.1. I measured the remains of the tested samples from over the past several years, recording all of their lengths, and matching them with the conditions of their test environment in a large spreadsheet.
   1.2. After doing this it was realized that many of the old samples were the wrong size and shape and did not match any ASTM standard dogbone. Not only that, but some had been vapor annealed, and some simply had no notes on them. I compiled the lengths for all of them, but as it worked out there were never more than a few of any one distinct sample, so trying to compare them to the injection molds was going to be difficult.
2. After compiling the old tests, it was decided that new filament would be extruded, and some more tests should be conducted using standardized sample geometries. Upon requesting that some more filament be extruded, Dr. Armando McDonald politely declined, citing that he was already far too pressed for time to get the extruder running again.
   2.1. At this point I approached the individual in the Buchanan Engineering Lab who helped 3D print the previous samples. Upon discussing the project with him and asking whether there was any leftover filament from the custom stock that was made before I joined the project, he replied that it had never been used and that the samples had been printed with brand name filament. In other words, our non-standard samples were not made out of the same ABS plastic, probably due to a slight breakdown in communication several years ago.
3. It was at this juncture that it seemed prudent of us to pursue microtomy of the old 3D printed samples, simply to at least get an idea of where to go with the research.

3.1. I began by asking around McClure, only to find that the microtome we thought was there had been surplussed several years ago. I reached out to the biology department, but turned attention toward WSU's Electron Microscopy Lab.

3.2. We knew that the ABS samples would need to be stained with Osmium Tetroxide, but when we tried to find anyone with a working knowledge of Osmium Tetroxide staining, we came up empty handed, including at WSU. It was proposed that I could go and pay for the training to use the SEM at WSU, but that would require a semester long course for which there simply was not time.

In the end, the conclusion of the Spring semester rolled around and Dr. Roll and I had hit nothing but dead ends in the course of the project. I express my sincerest apologies, as I had high hopes of being successful with this research. However, Dr. Roll has informed me that this is not unheard of.

Summary of Budget Expenditures:

Stock Material Costs: ABS $62.83 per 5 kg bag	$62.83
Stock Material Costs: Transparent ABS Filament $29.95 per roll	$29.95
Microscopy Supplies & Maintenance Costs	$225
Total*	**$317.78**

*Unspent funds were returned at end of funding period

Conference Presentations: Regretfully, I did not have any results in time to present at ICUR 2019 so I did not attend/present a poster at this conference. My plan is to continue research in Dr. Roll's laboratory this fall semester and present my results at the UI Undergraduate Research Symposium in Spring 2020.

Acknowledgement: I greatly appreciate the generous support provided to me by the Idaho State Board of Education/HERC in the form of an Undergraduate Research Grant from the U of I Office of Undergraduate Research. I truly appreciate this opportunity, and despite the misadventures along the way, I learned a lot and this experience meant quite a lot to me. This research, although occasionally troublesome, was of tangible benefit to my college career.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) - Summer 2019

Fellowship Recipient: Jacob Alderink, Computer Science, University of Idaho

Faculty Mentor: Terence Soule, Professor and Chair of Computer Science Department

Project Title: Examining the Behavior of Evolutionary Algorithms in the Starcraft II Environment

Abstract: Autonomous software has become a large part of everyday society. They drive our cars, deliver our packages, fly drones, and maintain our economy. These robots need to learn at both an individual scale but also learn how all the robots need to work together at a management scale. Evolutionary AI techniques could solve the problems that come with maintaining and teaching these robots. Starcraft provides a testbed for AI behavior analysis. Starcraft requires the player to create a military infrastructure, manage an army at both the micro and macro level, and collect and administer resources. Using Starcraft we examine the best method for evolving two algorithms a macro algorithm and a micro algorithm. For our results we examined: running the micro algorithm by itself, the macro algorithm by itself, running them both in parallel, running the macro algorithm for a short time then having the micro come in, and finally running them both separately and then combining them after a set amount of generations. Our results indicate that parallel evolutionary algorithms with interdependent goals learn best when infrastructure is learned solo, and then unit behavior is defined.

Project Design: The evolutionary algorithm is two-fold. One algorithm is in charge of developing the overall strategy that this bot takes (The Macro Algorithm). The second algorithm is in charge of developing strategy for the individual unit groups that the first algorithm produces (The Micro Algorithm). The Macro Algorithm is a Genetic Algorithm (GA) in which each individual is 100 integers long. Each integer ranging from 0-32 represents a building or unit that it wishes to produce. Once the game is started, the GA starts at the first gene in the selected individual and takes the number there and translates it to a corresponding unit/building. If it can build it, the game then produces that unit. If it can't (due to tech tree issues or possibly missing resources) then a fitness penalty is administered. Since the ultimate goal of the Macro Algorithm is to produce an army, every unit that is produced adds to the fitness of the individual.

The Micro Algorithm is also a GA in which each individual is (149*18) = 2682, float values long ranging between -1.0 and 1.0. These values are weights inputted in a neural network that are trained through evolutionary methods to determine the behavior of every type of unit in the game. Since the bot is protoss there are 18 unique army units that are in the game that need to have their behavior trained hence the 18. The neural network itself is 2 hidden layers with 11 inputs and 5 outputs. Information input into the neural network is:

Table 1: Neural Network Input Table

Input List	Format
Unit Position	(x,y)
Group Center Position	(x,y)
Enemy Start Location	(x,y)
Location Of Nearest Enemy	(x,y)
Percent of Health Remaining	Float(0.0-1.0)
Number of Adjacent Allies	Integer
Number of Adjacent Enemies	Integer

The output information is encoded as such:

Table 2: Neural Network Output Table

Input List	Format
Position to Go To	(x,y)
Execute Unit Ability	Float(0.0-1.0)
Attack or Move to Location	Float(0.0-1.0)
Attack Closest Enemy	Float(0.0-1.0)

Project Results: The method that produced the best results was when the Macro trained alone for 30 generations and then started training with the Micro algorithm. This indicates that autonomous AI programs that need to train with other algorithms will do best if the algorithm that creates infrastructure is trained alone first and the individual behavior algorithms are then attached.

Table 3: Results

Format	Generation .5 Ratio Was Reached On
Macro Alone Followed by Micro	Generation 55
Micro Alone Followed by Macro	Generation 99
Both Trained in Parallel	Generation 71
Both Trained Separate then Combined	Not Reached after 120 generations

It reached a 50% win loss ratio against the HARD bot at 55 generations which is 15 generations before the next method did. This potentially happens because the micro algorithm is more heavily dependent upon the macro algorithm to work. If there are no units produced by the macro algorithm, then for the first set of generations the micro algorithm might learn the wrong things. Thus, the macro-algorithm training by itself would create an environment so that when the micro does come it, it has units and behaviors to improve and train upon.

Conference Presentation: This study was presented as a poster at ICUR in July 2019.

Project Budget:

Item	Cost
SURF Fellowship	$4,000
ICUR Poster	$89.04

Acknowledgement: I truly appreciate the generous support provided by the State Board of Education/HERC in the form of a Summer Undergraduate Research Fellowship from the UI Office of Undergraduate Research. This was a tremendous experience for me. Without this support from the SBOE, I would not have been able to participate in this research.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) - Summer 2019

Fellowship Recipient: Jennavere Ball, Movement Sciences, University of Idaho

Faculty Member: Dr. Chantal Vella, Associate Professor, Department of Movement Sciences

Project Title: Associations of sedentary behavior and skeletal muscle mass in middle-aged to older adults

Abstract:
PURPOSE: To examine the associations of muscle mass and risk factors for sarcopenia with time spent in sedentary behaviors in middle-aged to older adults. **METHODS:** 12 adults (mean±SD: age: 56±9.5 y; 83% women) visited the laboratory on two occasions where anthropometrics, body composition, and blood glucose, hemoglobin A1c, and lipids were measured. Skeletal muscle index (SMI), total skeletal muscle, lean, and fat mass, as well as segmental lean and fat mass were estimated with a multi-frequency bioelectrical impedance analyzer. Sedentary behavior (SB) and moderate-to-vigorous physical activity (MVPA) were objectively measured for 7 days using a triaxial accelerometer worn on the right hip. Simple correlations were used to examine the associations between SB and variables related to lean body mass. **RESULTS:** On average, participants were classified as overweight with a body mass index of 29.1±5.1 kg/m^2 and body fat percentage of 36.6±8.4%. Participants had adequate skeletal muscle in the arms and legs indexed to height, as indicated by a SMI of 7.62±1.02 kg/m^2. On average, participants spent 494.6±75.5 $min \cdot d^{-1}$ in SB and 59.18±26.3 $min \cdot d^{-1}$ in MVPA. SB was positively correlated with skeletal muscle mass (r=0.35), SMI (r=0.51), and lean mass in the left leg (r=0.25), right leg (r=0.27), and trunk (r=0.40); however, these associations were not statistically significant (p>0.05 for all). **CONCLUSIONS:** Although our data show SB had low-to-moderate positive correlations with lean mass, these were not statistically significant and were in the opposite direction of our hypotheses. A larger sample size is necessary to draw conclusions regarding these preliminary findings.

Project description:

It is known that increased sedentary behavior has been positively related to many negative health outcomes. The effects of sedentary behavior have been shown to have negative outcomes on health even if an individual meets the recommended guidelines of 150 min per week of moderate-to-vigorous physical activity (MVPA). Although several studies have investigated the associations between sedentary behavior and body composition, a majority of these studies only examine body fat and fail to consider lean mass. Lean mass is composed of skeletal muscle, bone, and water. Sarcopenia, defined as gradual muscle loss with age, is related to the inability to perform activities of daily living with ease and loss of independence. Few studies have examined the relationship between sedentary behavior and risk factors for sarcopenia, and those that have are limited because of the use of self-reported levels of sedentary behavior. The purpose of this study was to determine the associations between total sedentary behavior and bouts of sedentary behavior with markers of muscle health, while controlling for risk factors, such as age, physical activity, diet, and self-reported diagnosis of chronic disease in middle-aged to older adults. The term "bouts" refers to the total number of times when a participant sits for an extended period of time. In this study we specify how many 10, 20, 30, 40, 50, and 60-minute sedentary bouts over the course of a week. Results of this study may help fill a gap in the literature by determining whether sedentary behavior and muscle mass are associated.

Summary of project accomplishments:
Although our study start date was delayed, we have been successful recruiting participants. To date we have recruited 18 participants total: 12 out of the proposed 30 participants have completed the study, and 6 additional participants are currently in the study. Based on the success level of recruiting we believe that we will be collecting data for a few more months. A preliminary analysis of the data using the 12 participants with complete data showed that sedentary behavior was positively correlated with skeletal muscle mass (r=0.35), skeletal muscle index (r=0.51), lean mass in the left and right leg (r=0.26 and r=0.27 respectively), and lean mass in the trunk (r=0.40). However, these correlations are not statistically significant, likely due to our small sample size. Additionally, we have not yet accounted for covariates in the model due to this small sample size. We hypothesize these correlations will decrease and possibly become negative as we gain more data. We will continue to collect data for this study until at least 35 participants are completed as that should be enough data for statistical analyses.
Through this project I've also had some personal accomplishments. I have gained valuable leadership experience conducting this study and have become very proficient in health-related data collection procedures and working with human subjects. I have learned how to effectively communicate with participants to explain consent forms and testing procedures, conduct body composition assessments using multi-frequency bioelectrical impedance analysis, obtain blood samples via finger stick for testing of blood sugar and fats, and collect and process activity monitor data. I have learned firsthand what the research process entails from the work that goes into developing a research question and methodology, organizing data, and analyzing and communicating results. I have also learned how much dedication working with a close-knit team takes and how to communicate with each other to have the study run smoothly. Although, I have been with Dr. Vella's lab for about a year now, I have learned the most during these last 2 months where I have had the opportunity to take the lead on every aspect of this study.

Summary of budget:
Of the $1,000 project budget, $700 of our budget went to participant gift cards as incentive to complete the study. The rest of the budget ($300) was used to pay for costs associated with the blood draws. The poster printing costs for the U of I Undergraduate Research Symposium will be paid out of my mentor's lab account as we don't anticipant printing the poster until spring semester. TOTAL EXPENDITURES: $1,000 project budget + $4,000 fellowship = $5,000.

Poster presentation at ICUR 2019:
Dr. Pfeiffer, Director of the Office of Undergraduate Research, gave me permission to miss the Idaho Undergraduate Research Conference in Boise for extenuating circumstances; however, I will present a poster at the UI Undergraduate Research Symposium in April of 2020 detailing the results of my study.

Acknowledgment:
I truly appreciate the generous support provided by the State Board of Education in the form of a SURF award from the UI Office of Undergraduate Research. Without this support from the SBOE/HERC, I would not have been able to participate in this research.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) - Summer 2019

Fellowship Recipient: Chanelle Brusseau, Animal Veterinary Science and Pre-Vet, University of Idaho

Faculty Member: Dr. Karen Launchbaugh, Professor, Rangeland Ecology

Project Title: Examining visual cues and cattle responses for virtual fences

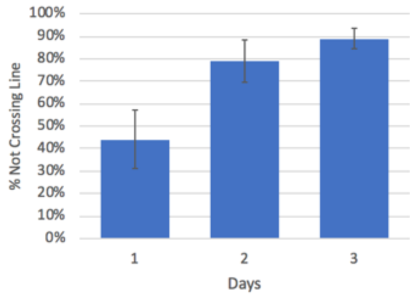
ABSTRACT:
Virtual Fence is a new, innovative, and advanced technology designed to enclose grazing cattle with less labor and lower negative ecological effects than conventional wire fences. A student-professor team is developing an electronically advanced nose clip attached to livestock eliciting electrical stimulus when animals' cross virtual boundaries. My research advances our design by examining visual cues to facilitate animal learning. I conducted research to address two questions: 1) Will cows avoid visual barriers after receiving electrical shock to the nose? 2) Will animals recognize and stop at unconnected objects of varying distances as visual cues for a barrier? We found that after 3 days of training, where animals received a shocked after crossing a line on the ground, 89-91% of cows, depending on circumstances, would stop at that line. It was also discovered that in experiments with unconnected posts in various locations, animals were still able to avoid a visual barrier with 91% and higher success rate. Overall, we can conclude that cows are able to use differing visual cues to perceive a virtual barrier between unconnected objects. Results will be used by the UI Virtual Fence team to advance our design for ranchers to use on grazing lands. A manuscript is being prepared for a publication in a refereed journal and guidelines will be developed to help ranchers use visual cues to train animals for virtual fences.

Project Description
Since livestock were domesticated 10,000 years ago, humans have engaged in animal husbandry to provide materials and food to humans. In the late 1800's, ranchers began using a new technology called, "barbed wire" to keep animals enclosed and graze in certain areas. Electrical fencing was introduced in the 1930 as an alternative to heavy wire fences. Fast forward to the 2000's, we see the agriculture industry using more electronically integrated technologies. Precision technology is also being developed for ranchers to manage livestock movement by using what is known as "virtual fence" which is designed to keep cattle out of or inside an area with a device worn by the animal that receives a signal when animal breaches a designated boundary and administers an electrical shock. My research examined if cattle can perceive a line on the ground, or unconnected points, as a barrier in a virtual fence.

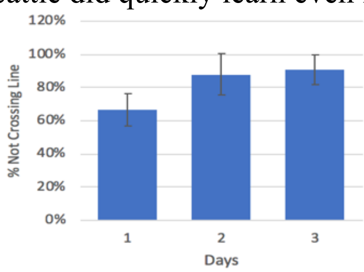
Experimental Procedures and Accomplishments:
Animals used for this research were the University of Idaho's Charolais beef cows (n=29) whose age ranged from 2 to 10-years-old and weighed 650 to 850 kg. Protocols were approved by IACUC (Protocol #IACUC-2018-25) in February 2019. We used a Sport Dog YardTrainer 350 training dog collar connected to a nose clip by wire leads to emit an electrical shock at 4.7 kv, no resistance.

Before the experiments, we introduced cattle to molasses COB (i.e., corn, oats, barley) grain and observed and recorded cows' individual responses to distractions, nervousness, and motivation to eat grain. From these data we selected 18 animals most suited for the experiments. In all experiments, we haltered cattle and applied a nose clip to deliver an electrical stimulus. Cows were released from the working pen and moved to a treatment zone where they were observed and encouraged to cross a boundary line into an exclusion zone marked by a visual line or barrier with posts. In in experiments 1-4 there were grain pans in the exclusion zone to encourage cows to cross the barrier and enter the zone. In experiment 5, the grain pans were not present, but 10 other cows from the herd were held beyond the exclusion zone to draw cattle into the zone. Each day, cows were tested 4 times and places in a reset zone between runs. After trials, cows had halters and nose clip removed and were released to pasture.

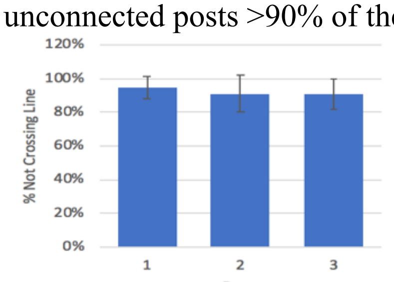
Experiment 1: We examined if cattle stop at a line in an alley after receiving an electrical shock and how long it would take them to learn this behavior. We tested 18 cows 4 times each day (30 sec/run) until >85% of them didn't cross the line. During the experiment we found that more cows stopped at the visual line on the ground each day (P<0.05) until day 3 when 89% of animals stopped (Figure 1). These results indicate that cows were able to learn to stop at a line in only a few days



Experiment 2: Like experiment 1, cows were encouraged to cross a line receiving a shock if they crossed that line. However, in this experiment we wanted to know if animals would still stop at a line in a larger area (corral) rather than a narrow alley. Each cow (n=16) was tested 4 times per day. We observed that cattle did quickly learn even in a larger area. By day 3 cattle stopped at the line >90% of the time. (Fig 2).

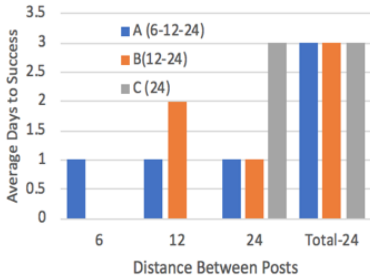


Experiment 3: In this experiment we examined if cattle would stop at unconnected posts instead of a line on the ground. Cattle were encouraged to cross a line posts spaced 1.5-meters apart in a corral. Each cow (n=16) had 4 runs/day (30 sec./run). We found that the cows throughout this trial stopped at the unconnected posts >90% of the time (Figure 3), indicating that cows perceive a virtual boundary.

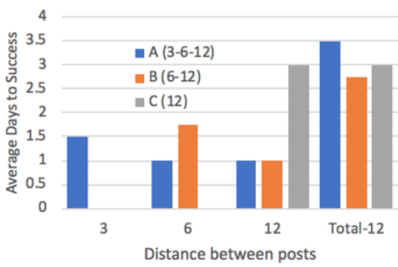


Experiment 4: In this experiment we increased the distance between posts to examine if animals perceive this as a boundary. Posts were spaced 6, 12 and 24 meters apart in a pasture. Cows started at a set distance and progressed a greater distance after not crossing the line 18 out of 20 times per group of five cows. Cattle were placed into 3 groups: 1) 6 → 12 → 24 meters, 2) 12 → 24 meters, and 3) 24 meters. Cows had 4 runs/day (2 min./run). We found that animals take about 3 days to learn to stop at a distance of 24

meters between posts (Figure 4). Previous experience at shorter distances doesn't decrease the time it took to perceive a barrier at 24 meters. There was concern that feed pans placed directly behind the line of posts indicated a virtual boundary to the cows.



Experiment 5: In the final trial, we removed feed pans from the exclusion zone to ensure they were not acting as visual cues for the boundary. Cows (n=15) were encouraged to cross posts spaced at 3, 6, and 12 meters apart in a pasture. To ensure cows in the trial cross into the exclusion zone we placed 10 other cows in the herd beyond the exclusion zone. As above, cows started at set distance and advanced to greater distance. Cows were in groups: 1) 3 → 6 → 12 meters, 2) 6 → 12 meters, and 3) 12 meters. Cows had 5 runs/day (2 min./run). Cows individually moved up to a greater distance when they didn't cross the line 4 or more times out of 5 runs. Animals took about 3 days to not cross the line at >91% (Figure 5). Previous experience with different distance smaller than 12-meters didn't decrease the days it took to stop at 12 meters.



In summary, I found that cattle learn very quickly with simple designs and they have the knowledge to remember what they learned to apply it to other situations. I will continue this research with my fellow teammates through the fall to discover more to help better the Virtual Fence Project.

Budget expenditures:

Type of Expense	Cost
Feed for experiments	$247.16
Field equipment	$ 238.68
Fuel for travel to site	$ 45.72
SportDog Collars-2	$299.98
Total	**$ 831.54**

Conference Presentation: I informed both Patricia Tilden and Dr. David Pfeiffer that I was not able to attend the ICUR 2019, however I'll present my findings in the Poster Symposium during the school year.

Acknowledgments: I appreciate this SURF grant that allowed me to explore science in a way I have never been exposed to, allow me to work with an interdisciplinary team, and spend time outside working with livestock to better the agriculture industry. Thank you to our professors on the project Dr. Karen Launchbaugh and Dr. Gordon Murdoch for all you help and support along with the UI Beef Manager Zane Garner for your cooperation.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) - Summer 2019

Fellowship Recipient: Courtney Carter, Animal Veterinary Science, University of Idaho

Faculty Mentor: Dr. Gordan Murdoch, Professor, Animal & Veterinary Science

Project Title: Audio Cues and its Application to Virtual Fence

Abstract: Virtual fence as defined in this project, is an animal-worn device that detects the animal's location relative to a virtual boundary and delivers an electric stimulus if crossed. This technology has the potential to improve management practices for grazing livestock. It could allow producers to use grazing areas that are otherwise unusable because they would be difficult or too expensive to fence. My research focused on audio cues applied before an electrical stimulus to signal a pending shock and facilitate avoidance behavior. The specific aims were to determine: (1) If sound, paired with an electric shock was an effective associative cue for cattle; (2) Does the tone and duration of the sound cue change its effectiveness; (3) Does the direction/location of sound affect associative learning in cattle. In experiment 1, 57% of cattle paused for at least two seconds after hearing a sound, 38% paused at the shock, and 5% didn't pause at all. In Experiment 2, 91% of cattle paused when they heard a 2,000 Hz beep, 78% paused to the sound of an air horn, 77% paused to a 300 Hz beep, and 66% paused a tolling bell. In experiment 3, 97% of animals paused if the sound came from in font vs 86% paused when the sound came from behind the animal. Animals were no more likely to pause if the sound came from near one ear (78% paused) compare to sound from near both ear (66% of animals paused).

Project Description and Accomplishments:
In early times, people used wood and stones to build fences to keep animals out of crop areas and contain them within pastures. Once westward expansion started, barbed wire fences became popular due to the lack of wood and stones in the plains. Fences are known to cause issues with wildlife by disrupting natural migration routes, inhibiting access to natural habitats, and entangling animals resulting in their death. These fence issues have contributed to population decreases in some wildlife species (Hanophy, 2009). Fences are also expensive to build and maintain. This has led researchers from across the globe to search for a way to manage livestock without physical fence. The idea of virtual fence gave is a potential solution though there are still concerns to be addressed. For example, several animal welfare concerns have prohibited the use of shock collars for training dogs in several countries and may limit use of virtual fences where electrical stimulus is used (Umstatter, 2011). Specific concerns include animals getting repeated electric stimulus due to faulty devices, inadequate training of animals, and the amount of distress animals may face when the electric stimuli are random (Umstatter, 2011).

1. Training animals to stop at a sound that is associated with a shock. Animals were enticed down an alley with grain and peers. Once they crossed a designated boundary, a sound was emitted. The distance to the boundary changed each time cattle walked down the alley. We recorded whether the animal paused at the sound, shock received after the sound, or didn't pause at all. Each animal repeated this, four times per day for four days. A Chi-Square analysis of pausing showed that day had no effect on whether the animals paused or didn't pause at the sound ($P=0.90$). This indicates that animals didn't learn to stop at a sound.

2. Will changing the tone or sound change the response to an associated sound and shock? As above, animals were enticed down an alley and a sound was emitted. We recorded whether or not the animal paused at the sound or shock. This was repeated four times each day for four days. A Chi-Square analysis of pausing vs not pausing showed a difference between sounds whether the animal paused or not

(P=0.013). When a 2,000 Hz beep was played, 70% of cattle paused, 63% paused to the sound of an air horn, 55% paused to a 300 Hz beep, and 46% paused a tolling bell.

3. Will the direction from where the animals hear a sound, change the response to an associated sound and shock? As above animals were enticed down an ally, and a sound was emitted. This was repeated for each animal four times per day for four days. In this experiment, sounds varied by the location from which they were emitted. When a sound was emitted from behind or in front of the animal, 97% of animals paused if the sound came from in front of versus 86% that paused when the sound came from behind the animal (P=0.03). It appears that animals were no more likely to pause if the sound came from near one ear (78% paused) compare to sound from near both ears (66% of animals pause: P=0.12) though based on the small sample size this may be prone to type 2 error.

Based on experiments conducted this summer, I believe future research can further evaluate effective use of sound in the most efficient way by using tones close to 2,000 Hz and have them emitted from the front of the animal. However, I also learned that cows don't inherently, nor do they quickly develop an association between the sound and the shock. This makes me question the types of virtual fence that are becoming commercially available that are based just on sound. Our team will look further into animal behavior and the best way to train them to make that association.

Conference Presentation: This study was presented as a poster at ICUR in July 2019.

Budget Expenditures:

Item	Price
Halters	$ 47.97
Training Collars	$458.93
Duct Tape	$ 12.93
Rolled Barley	$ 140.44
Batteries	$ 22.99
12-gallon Tote	$ 11.95
Poster Printing	$70.00
SURF Fellowship	$4,000
Total	$4,792.21

Acknowledgment: I greatly appreciate the generous support provided by the SBoE/HERC that made my SURF award this experience possible for me. It was a truly great experience.

References :

Hanophy, W. 2009. Fencing with Wildlife in Mind. Colorado Div. Wildlife, Denver, CO. 36 pp
Umstatter, C. 2011. The Evolution of Virtual Fences: A Review. *Computers and Electronics in Agriculture,* vol. 75(1);10-22

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) - Summer 2019

Fellowship Recipient: Abby L. Davis, Animal and Veterinary Science, University of Idaho

Faculty Mentor: Dr. Brenda Murdoch, Dept. Animal & Veterinary Science

Project Title: Understanding how genetic variation in PRDM9 affects meiotic recombination

Project Description:
Meiotic recombination is an important process that contributes to genetic variation and produces viable gametes. Errors due to abnormal or improper recombination can result in reproductive consequences such as aneuploidy, developmental issues, fetal loss, and infertility (Baudat et al. 2013). The driving force behind this project is that very little is known about the influencing factors of meiotic recombination in mammals. Improving our knowledge regarding the effect of genetic variation on the meiotic recombination gene PR/SET domain 9 (PRDM9), the gene thought to be responsible for the positioning of recombination hotspots, can provide valuable insight regarding male infertility in both livestock and humans.

A recent study characterized and quantified the recombination protein mutL homologue 1 (MLH1), which is thought to be indicative of crossover (CO) events (Davenport et al. 2018). Davenport et al compared the number of COs per spermatocyte from three different breeds of sheep (Suffolk, Icelandic, and Targhee). The results of their study indicated that the number and location of MLH1 foci varied amongst the three different breeds. Suffolk rams exhibited the lowest number of MLH1 foci, followed by Icelandic rams, and lastly Targhee rams exhibited the highest number of MLH1 foci. The objective of this study is to expand on previous work by utilizing immunofluorescence to identify and characterize the histone mark, histone3 lysine4 trimethylation (H3K4me3), of PRDM9 using male meiotic prophase cells from Suffolk and Targhee breeds of sheep. H3K4me3 is thought to be the histone catalyzed by PRDM9 during meiotic prophase, (Davenport et al. 2018). We hypothesized that different breeds of sheep would express different H3K4me3 intensities, and that those breeds of sheep that exhibit higher MLH1 numbers also exhibit higher H3K4me3 intensities.

Testicular tissue samples of sexually mature Suffolk and Targhee rams were collected postmortem. The samples underwent surface spread preparation and were either frozen for later use or were immediately stained. Immunofluorescence staining was performed to identify three proteins: synaptonemal complex protein 3 (SYCP3), H3K4me3, and chromatin. Imaging of the meiotic prophase cells was done through the use of a Leica DM6 B fluorescence microscope and an Andor Zyla sCMOS camera. Throughout this study we imaged cells in the pachytene stage of prophase where MLH1 is thought to be initiating double strand break repairs through CO pathways (Baudat et al. 2013). The average intensity of the H3K4me3 signal was calculated per spermatocyte for each of four Suffolk and four Targhee rams using ImageJ version 1.51 software. Out of the four Suffolk and four Targhee rams utilized, approximately 50 spermatocytes per individual were examined, totaling 205 spermatocytes per breed. Using R Studio version 3.3.3, three statistical analysis were performed to determine if a significant ($p<0.05$) difference in H3K4me3 intensities were present. The first test was a Shapiro Wilk Normality test to determine if the data set was of a normal distribution. Following this test, a Kruskal-Wallis test and a post-hoc Tukey-Kramer test were performed to identify any significance within the data. This data was then compared to previously reported MLH1 data that underwent the same statistical analysis (Davenport et al. 2018). To identify any correlation between MLH1 and H3K4me3 data, a Spearman's Rank Correlation was also performed.

The mean H3K4me3 intensity for Suffolk and Targhee spermatocytes were 17,552.15 and 17,678.44, respectively. The average difference of intensity measures for each breed were 15,593.19 for Suffolk and 18,362.32 for Targhee. The Shapiro Wilk Normality test indicated that the data did not show a normal distribution. The Kruskal-Wallis test and the post-hoc Tuckey- Kramer test indicated that a significant difference of H3K4me3 signal was present amongst individuals. Reference Figure 1 for a visual representation of the significant differences found. The Spearman's Rank Correlation resulted in a p-value of p=0.4198, showing no significant (p>0.05) correlation between previously reported MLH1 numbers and locations and H3K4me3 intensities.

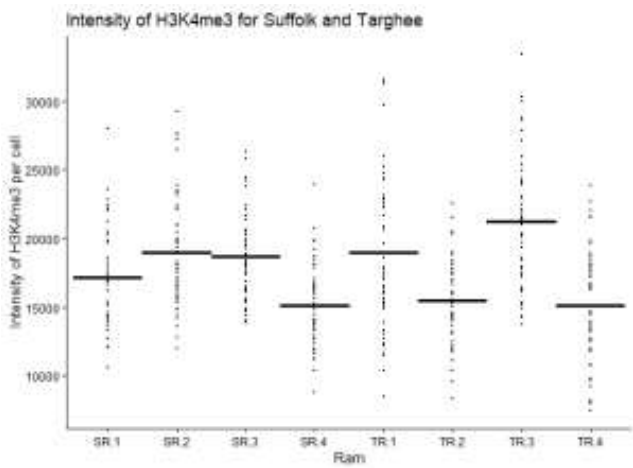


Figure 1. H3K4me3 intensity averages in individual rams. The dots represent the intensity average of each spermatocyte per individual. The black lines represent the mean intensity per individual. A, B, and C indicate significant (p<0.05) differences.

Accomplishments:

Through this research, we were able to conclude that significant differences of H3K4me3 intensities were observed amongst individuals of both Suffolk and Targhee sheep. However, no significant correlation to the previously reported MLH1 data was present. A better understanding of the relationship between H3K4me3 and MLH1 was developed, but it is still unclear how variations among these proteins control or influence PRDM9. This study contributes to the overall understanding of PRDM9 as well as sets a precedence for future work. As a student, I gained a more in-depth knowledge of the process of meiotic recombination and the many factors that contribute to it. I also had the opportunity to improve my bench work skills as well as obtain one on one training in advanced cytogenetic techniques and fluorescence microscopy. This was a summer of growth, and I am grateful to have had the opportunity to learn from such great mentors. I am thankful to have gotten the opportunity to participate in this research project. I sincerely thank the ID SBoE for providing the funding that made this possible!

Budget Expenditures

Item	Size/Amount	Cost per item	Total cost	Supplier
ProLong Gold Antifade Mountant with DAPI	1 bottle 10 ml	$211	$211	Thermo Fisher
Microscope slides	5 packs of 114 slides	$75	$375	Fisher Scientific
SCIENCEEARE Spindrive Orital Shaker	1	$381.52	$381.52	VWR
Poster printing	1	$70	$70	
SURF Fellowship			$4,000	
TOTAL			$5,037.52*	

*$5,000 covered by SURF award, remaining $37,52 covered by mentor.

References

Baudat, F., Imai, Y., & De Massy, B. (2013). Meiotic recombination in mammals: localization and regulation. Nature Reviews Genetics, 14(11), 794.

Davenport, K. M., et al., (2018). Meiotic recombination differences in rams from three breeds of sheep in the US. Cytogenetic and Genome Research. DOI:10.1159/000493175

Hassold, T., & Hunt, P. (2001). To err (meiotically) is human: the genesis of huma aneuploidy. Nature Reviews Genetics, 2(4), 280.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) - Summer 2019

Fellowship Recipient: Kathryne Day, Animal and Veterinary Science, University of Idaho

Faculty Mentor: Dr. Pedram Rezaman, Dept. Animal and Veterinary Science

Project Title: Nutritional characteristics of a modified lignin product

Abstract

The objective of this preliminary study was to evaluate feeding behavior of Holstein dairy heifers when offered a lignin product as a component of pelleted feed. Five feed pellets were prepared: a positive control containing molasses, a negative control containing neither molasses nor the product, and three pellets containing the product in varying levels – low, medium, high – plus molasses. Growing Holstein heifers (16 months of age, average BW = 399 ± 9 kg) were placed into individual pens (3 x 5 meters) with one pelleted feed offered at a time to test the acceptability of each feed. Feeding behaviors were recorded for each animal in a specified amount of time (60 min). A total of 129 observations were statistically analyzed. Preliminary data show the animals accepted the pelleted feed containing the high inclusion lignin product more than the other feeds: heifers consumed more feed within 60 minutes ($P < 0.0001$) and per approach ($P < 0.0001$). Heifers spent less time ruminating ($P < 0.0006$) and eating ($P < 0.0001$) when the negative control was offered compared with that of other feeds except the low inclusion. We are currently evaluating rumen fermentation characteristics of pelleted feeds containing the modified lignin product.

Project Description

All plant material is made of cellulose, lignin, and hemicellulose. Cellulose and hemicellulose are made of glucose molecules bound by β-linkages. Most mammals lack the enzymes to break the bonds between the glucose molecules. Cattle contain microbes in there stomach that ferment cellulose and hemicellulose and convert them to volatile fatty acids that the animal can convert to glucose and ATP. However, there are always losses as the microbes cannot remove all the cellulose from the lignin. These losses can be detrimental, especially in dairy cattle. High-producing dairy cows struggle to eat enough nutrients to supply their maintenance requirements and produce milk. The cows need as much readily available food as possible. As such, many companies have worked and developed products that remove the cellulose from the lignin. One company has created a process to thermally and chemically modify products high in lignin – such as wood chips and wheat straw – and make them more degradable. The process creates a liquid mixture that could be used as a binding agent to replace molasses in pelleted feed.

This project used the modified lignin from the above process to make a feed pellet, observing how well the pellet binds. An acceptability test was performed on the pellet; heifers were observed on how they respond to this new feed. The pellets will be analyzed in vitro for digestibility and fermentability. Finally, a palatability test will be performed: heifers will be observed on how they respond to a feed while the negative control is present.

Project Accomplishments

Five feed pellets were developed using the heifer ration. The negative control did not contain the product or molasses. The positive control contained molasses. Three test pellets containing various levels of the product – high, medium, and low – as well as molasses.

An acceptability trial was performed using eight growing Holstein heifers 16 months of age and 30 days pregnant. The animals were removed from feed at least 30 minutes prior to each feeding. Each animal was individually placed in a pen (3.4 x 3.7 meters) with a feed. The order of animals and feeds were randomized. The feeds were weighed before and after each trial and then converted to dry matter intake. The animals were left with the feed for 45-60 minutes and recorded via camcorder. The video was analyzed for the time the animals spent eating, ruminating, wandering, drinking, and the number of approaches to the feed. The preliminary data show that the animals accepted the new product. They ate more of the high inclusion lignin product than the others ($P < 0.0001$). The animals spent more time eating ($P < 0.0001$) when in the pen with the high inclusion lignin product. The animals approached and ate the high inclusion lignin product more than the other feeds ($P < 0.0001$).

Two cannulated beef heifers were fed a Holstein heifer ration for one week. Then rumen fluid was collected to perform *in vitro* analysis. The samples were placed in the rumen fluid for varying amounts of time – 3, 6, 9, 12, 18, 24, and 48 hours – and then analyzed for fiber degradation and organic matter degradation. They were compared to the original sample degradation values. *In vitro* data is still preliminary and has not been statistically analyzed. More replications are required and will be performed over the next few weeks. The volatile fatty acids have not been analyzed yet as the GC machine was being used for another project. The palatability trial will begin August 9, 2019. The feeding portion of the trial should be complete by August 30, 2019. All the videos should then be analyzed by the end of September. The project is still ongoing under the supervision of Dr. Rezamand and three of his students.

Conference Presentations:
I presented a poster of my work at the Idaho Conference on Undergraduate Research (ICUR) in Boise in July 2019.

Budget Expenditures

price	Unit	Test	amount	additional units	
$700.00	Pelleting Machine	Animal Trials			$700.00
$177.99	Camcorder	Animal trials	1	$10.68 (tax)	$188.67
$5.99	SD Card (16 GB)	Animal trials	1	$6.36 (tax)	$112.35
$100.00	Tripod	Animal trials	1		
$20.69	SD Card (128 GB)	Animal trials	1	$3.50 (shipping) $1.24 (tax)	$25.43
$80	ADS Concentrate	*in vitro*	2 bottles	$67.38 (shipping)	$397.38
$85	NDF Concentrate	*in vitro*	2 bottles		
$1.20	Filter bags	*in vitro*	400 bags	$13.69 (shipping)	493.69
$47	Poster	ICUR	1 poster	$3.60 (tube for travel)	$50.60
				Total	$1968.12

*Budget costs above the grant were covered by research gift in the AVS department.

Acknowledgements
I want to thank the Idaho Board of Education for their support of this project through the University of Idaho Summer Undergraduate Research Fellowship Grant. I learned the skills necessary to set up a project and explain the process to my coworkers. I also learned how to explain my project to those who have little to no experience in my field. Thank you again!

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) - Summer 2019

Fellowship Recipient: Iqbal Ahmer, Biological Sciences, University of Idaho

Faculty Mentor: Dr. Craig McGowan, Associate Professor, Department of Biological Sciences

Project Title: Anatomic coupling of locomotor and auditory neurons in desert kangaroo rats

Abstract: Acoustic stimuli-induced startle response in mammals may be modulated by vigilance and an elevated arousal state to allow for a more rapid acoustic stimulus-induced response in locomotor systems. Environmental modulation of this reflexive response may underpin defensive maneuvers in prey species. Though this phenomenon is found in many mammals, the nature of anatomical connectivity between auditory and locomotor neurons remains unclear in desert kangaroo rats. Identifying the neuroanatomical nature of this auditory-locomotor pathway is a major step towards understanding how species-specific anatomical and functional properties of this pathway may underpin success rate of kangaroo rats in the wild. To evaluate the anatomical connectivity, a trans-synaptic retrograde pseudorabies virus was injected into the right gastrocnemius muscle and induces the expression of green fluorescent protein in all presynaptic neurons that are synaptically connected to the afferent motor neuron of the muscle, whether they be motor or not. Following 5-7 days of recovery after viral injection, kangaroo rats were euthanized, and their brains removed, frozen and sectioned coronally. Tissue sections containing all central auditory nuclei were then mounted directly onto slides or immunohistochemically labeled to amplify visibility of GFP expression. Sections were imaged through a microscope where GFP expression was observed in motor nuclei within the brainstem and midbrain along with the cochlear nucleus, a key site for mediating the acoustic startle response. Slices from the auditory pathway were also taken to observe if there is further involvement of higher order auditory brain regions that may contribute to the acoustic startle in k-rats.

Project Description and Accomplishments:

Desert kangaroo rats (*dipodomys deserti)* are a desert adapted species that thrive off their ability to escape predators through evasive techniques. Evolutionary changes suggest that the kangaroo rat developed strong bipedal hops in relation to heightened auditory response when startled by predators. In this project, we hypothesize that a direct connection between the auditory system and motor neurons controlling the escape jump is what enables kangaroo rats to react at a faster rate than other small mammals under similar conditions. The goal of this project is to identify the neuroanatomical nature of a potential connection between the auditory and locomotor systems.

Live desert kangaroo rats collected by Craig McGowan and his research team from the Mojave Desert for their experiments were used. Samples were injected with a PRV-152 virus strain that infected nerve terminals at the neuromuscular junction that were connected to distal regions of the spine. The virus traveled up into the cervical region of the spine, onto the brain stem, where it then infected presynaptic neurons and subsequently motor and auditory cortices. After viral incubation period of 5-7 days, brains were perfused in a 4% paraformaldehyde with 30% sucrose solution that cryoprotected brain samples. Serial sections of the brains were sliced using a cryostat and stained using an immunohistochemistry protocol that expressed Green Fluorescent Protein (GFP) in brain slice samples.

The main takeaways from this project showed that using PRV-152, a trans-synaptic pseudorabies virus, allows labeling of any neural circuit. In our experiment, this viral tracer can label auditory brain stem neurons suggesting they are linked to motor neurons. By injecting PRV-152 virus in proximal limb segment of the gastrocnemius, a connection between the locomotor and auditory system was seen. Evidence from data supports anatomical connectivity that would underpin acoustic startle response in kangaroo rats.

Expression was found in KRAT 1 sample at specific locations throughout the brain. Strong expression was found in reticular motor nuclei in posterior components of the brain that initially connected the brainstem and spine. Expression associated with movement was found in Nucleus raphe ragnus (RM), Nucleus raphe padillus (RPA), Magnocellular reticular nucleus (MARN), Gigantocellular reticular nucleus (GRN), Intermediate reticular nucleus (IRN), Parvicellular reticular nucleus (PARN). Additionally, expression was also presented in other portions such as Facial motor nucleus (VII), Dorsal cochlear nucleus (DCN), Ventral cochlear nucleus (VCN). The dorsal and ventral cochlear nucleus were one of the main components associated with auditory neurons and were a main component of startle circuit response. Expression was found in periaqueductal gray (PAG) which plays a critical role in autonomic function, motivated behavior, and behavioral responses to threatening stimuli. Expression was also found in the substantia nigra (SNr) which is a structure located in the midbrain that plays a role in reward and movement.

Budget Expenditures:

- $65.78 – Sucrose Crystals
- $46.67 – Scissors
- $241.16 – Alexa Fluro GOAT Antibody
- $129.00 – GFP for staining
- $172.50 – Prolong GOLD for mounting slides.
- $47.48 – Biolite 24WELL plates
- $215.88 – IHC/ICC Block for IHC staining
- $7.50 – Dry Ice from Chemstores
- ~$74.00 – Poster
- SURF fellowship: $4,000
  TOTAL: $5,000

Conference Presentations:
I presented a poster of my work at the Idaho Conference on Undergraduate Research (ICUR) in Boise in July 2019.

Acknowledgements
I thank the Idaho Board of Education for their support of this project through the University of Idaho Summer Undergraduate Research Fellowship program. This has been a tremendous experience for me. Thank you!

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship - Summer 2019

Grant Recipient: Natalie M. Jaeger, Biological Sciences University of Idaho

Faculty Mentor: Douglas G. Cole, Professor, Department of Biological Sciences

Project Title: Optimizing Fatty Acid Production in Strains of *Euglena gracilis*

Abstract

A promising candidate for biofuel and nutritional supplements is the photosynthetic protist, *Euglena gracilis*. In addition to producing essential ω-3 polyunsaturated fatty acids *E. gracilis,* under certain conditions, produces high yield of waxy esters that can be used without modification as biofuel. *E. gracilis* also produces a range of fatty acids including those with methyl branching. Previous studies that focused on industrial lipid production examined the effect of autotrophic (photosynthesis only) and heterotrophic conditions. Our preliminary studies examined changes in fatty acid profile as a result of changing nutritional factors. In the current study, we compared these nutritional factors with different strains of *E. gracilis*, and the effects of environmental factors common to farming. *E. gracilis* can be grown under constant light, but to mimic outdoor farming they were grown in a 14:10 light:dark cycle. *E. gracilis* were also cultured at different temperatures to reflect different climes. Preliminary results show that artificial constant light negatively effects fatty acid production, and that temperature and strain choice critically effect growth rate.

Project Accomplishments

1. **Compared the relative amounts of various lipid groups in different strains of *E. gracilis***
   We harvested two strains of *E. gracilis* grown in identical conditions for comparison of the relative amounts of different lipid groups. This will be sent to Microbial ID for FAME analysis. The results will be used to determine the importance of strain choice on *E. gracilis* farming.
2. **Compared the effect of a light:dark cycle on *E. gracilis* relative lipid production**
   The relative amounts of different lipid groups were compared in cells that grew under 24 hr of light and cells that grew in a 14:10 light:dark cycle. The relative amounts were tested in duplicates. We found that the relative amounts of key fatty acid groups (odd-chain, essential, and methyl-branched) were lower in the *E. gracilis* grown in 24 hr of light than the amounts in the light:dark cycle.
3. **Compared the effect of temperature on *E. gracilis* relative lipid production**
   Two strains of *E. gracilis* were grown in 16.5°C and 26.5°C. They were harvested at stationary phase and will be sent of Microbial ID for FAME analysis and the results compared between the two strains. Another strain of *E. gracilis* from the Yukon is being isolated for comparison in the study.
4. **Compared the impact of nitrogen starvation on different strains of *E. gracilis***
   Two strains of *E. gracilis* were grown in four different nitrogen treatment groups: with nitrogen, without nitrogen, with only isoleucine, and with only alanine. These were harvested and will be sent to Microbial ID for FAME analysis. We will then compare the impact on different key lipid groups.

Conference Presentations

I presented a poster of my research at the 2019 Idaho Undergraduate Research Conference. I intend to present another poster of this project at the 2019 University of Idaho College of Science Research Symposium

Budget Expenditure Summary

0.20 µm syringe filters (35 in a partial pack)	$47.43
Autoclave bags, case of 200	$74.56
Autoclave tape, 10 rolls	$35.20
Transfer pipets, pack of 400	$58.48
Bottle-top 0.2 µm filter, 500 ml, case of 12	$127.84
0.2 µm Filtration units, 500 ml, case of 12	$106.97
0.2 µm Flitration units, 150 ml, case of 12	$115.97
Disposable beakers, 50 ml, pack of 100	$11.47
Acetone, 4 L	$23.23
Methanol, 4 L	$28.74
Sterile screwcap vials, 2 packs of 100	$100.00
Sharps container, 6	$26.34
Sterile microtiter plates, 96 well, case of 100	$224.44
Labeling Tape, 4 rolls	$18.93
Shipping	$9.10
SURF Stipend (before tax)	$4000.00

The grand total is $5,009.00; the extra $9.00 was paid by discretionary Cole lab funds.

Acknowledgements

I appreciate the generous support provided by the State Board of Education/HERC in the form of a Summer Undergraduate Research Fellowship. This has been a tremendous experience and without the support of the SBoE I would not have been able to participate. Thank you!

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) - Summer 2019

Fellowship Recipient: Laura Nutter, Chemistry, University of Idaho

Faculty Mentor: Dr. Kristopher Waynant, Chemistry Department

Project Title: Encapsulation of *Lactobacillus acidophilus* and *Lactobacillus casei* to Determine Cell Viability in a Hydrogel Biobead Matrix

Abstract:
Trichloroethylene (TCE), a commonly used industrial solvent, is a widespread, persistent, and carcinogenic groundwater pollutant. An effective treatment strategy for TCE contamination is bioremediation using reductively dechlorinating bacteria. However, during bioremediation changing pH levels can harm these degrading microbes. By incorporating the microbes into a polymer matrix, pH is buffered, and the microbes are protected. This study assessed the viability of model microorganisms (*Lactobacillus casei* and *Lactobacillus acidophilus*) in various compositions and molecular weights of polyvinyl alcohol (PVA) and sodium alginate (SA) hydrogels. A method to measure viability of bacteria cells in biobeads was developed. Viability was characterized using plate counts and optical density measurements. Preliminary data indicates increased viability in beads composed of higher molecular weight PVA. A second goal of the project was to determine if polymer modifications impact diffusion rates. Similarly sized ionic (methylene blue, metanil yellow) and neutral (caffeine) model compounds were used to investigate the effect of charge on diffusion. Diffusion of caffeine through hydrogel membranes was determined to be 40% slower in hydrogels containing bacterial cells than without biomass. Determination of encapsulated microbe viability assists in optimization of polymer formulations to better protect microbial consortia and improve degradation of contaminants.

Project Accomplishments

1. One of my goals was to create an effective method for encapsulation of *Lactobacillus acidophilus* and *Lactobacillus casei*.

   I was successful in creating and refining a method for aseptically inoculating the PVA and SA polymers with bacteria and forming beads by chemically cross linking the inoculated polymer for 10 minutes in a crosslinker of 5.5% $CaCl_2$ for SA beads and 2% $CaCl_2$ and saturated boric acid for beads comprised of both SA and PVA. These beads were successfully stored in MRS broth and PBS buffer, with no short term impact on viability.
2. To determine comparative cellular viability of different polymer blends and molecular weights.
   I was able to determine that in both 10% PVA 2% SA and 5% PVA 2% SA hydrogel beads that higher molecular weight PVA produced increased viability after 2 days in MRS broth compared to lower weights. I noticed the highest viability and number of cells in 4% SA beads.

3. To explore alternative methods of crosslinking the hydrogels.
   I successfully made small batches of beads crosslinked by repeated freeze/thaw cycles. This was done with 5% PVA, 10% PVA, and 5% PVA 2% SA. 10% PVA beads form more quickly than the other two polymers, requiring fewer cycles. Forming beads is most successful on copper plates in a -20 °C freezer. The inclusion of polyoxometalates in low concentrations increases crosslinking ability of freeze/thaw cycles despite minimal dissolution.

Summary of Budget Expenditures

Supplies	Cost
Single-Channel Miniflex Pump	$699.99
External Hot Plate Temperature Controller	$160.00
Isopropyl-beta-D-thiogalactopyranoside	$80.50
Beta-D-Galactose pentaacetate	$13.50
Sodium tungstate dihydrate	$100.00
Metanil yellow	$17.00
Methylene blue hydrate	$29.00
Supplies Subtotal	**$999.99**
Stipend	$4000.00
Total	**$4999.99**

Conference Presentation: I presented a poster of my work at the 2019 Idaho Conference on Undergraduate Research (ICUR) in Boise. I will be presenting a poster at the UI Undergraduate Research Symposium in April 2020.

Acknowledgement: I truly appreciate the generous support provided by the State Board of Education/HERC in the form of a Summer Undergraduate Research Fellowship. This was a tremendous experience for me. Without this support from the SBOE, I would not have been able to participate in this research. I am also very thankful to the U of I Office of Undergraduate Research for helping make this possible.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) - Summer 2019

Fellowship Recipient: Kate Seegmiller, Mechanical Engineering, University of Idaho

Faculty Mentor: Dr. Daniel Robertson, Department of Mechanical Engineering

Project Title: A novel assessment of maize strength through puncture testing

Abstract
Corn (maize) is one of the most important crops in the world. However, 5-20% of the annual corn yield is lost to stalk lodging. Stalk lodging is a phenomenon in which forces from wind or rain break crops, and tall, top-heavy crops are especially susceptible. In the past, researchers and plant breeders have examined this problem from an agronomic or biological standpoint. However, little progress has been made. One of the main impediments to this problem is the lack of a quantitative breeding metric for stalk strength. My summer research proposed a solution to this problem by investigating a new way to approximate the strength of each stalk by first examining the morphology of each stalk, using basic engineering theories. I accomplished this by performing puncture tests on a large sample of 1000 naturally-dried corn stalks. Each puncture test generates a force displacement graph, which can be analyzed to retrieve information such as diameter and rind thickness. This data was then analyzed by customizing a MATLAB algorithm. In particular, this algorithm created several values which combined the morphological values derived from the puncture tests (i.e. the moment of inertia and the section modulus) with the puncture resistance forces measured during testing. The results of this experiment showed that the puncture resistance-weighted values had a very strong correlation with stalk strength, and further testing and investigation would be of value.

Project Description:
Stalk lodging is a problem that affects some of the most important crops in the world. Lodging occurs when forces from wind or rain irreparably damage a crop, causing financial and food losses. One of the most essential crops affected by this phenomenon is maize, with 5-20% of the annual yield being lost due to lodging. This has long since prompted researchers to investigate methods of strengthening corn stalks, but several impediments still exist that prevent much progress from being made. One major problem is the lack of a quantitative breeding metric for breeders to assess lodging resistance. My summer research involved developing a novel technique to determine stalk strength that I believe could provide a solution for this issue.

This research employs puncture tests to evaluate maize stalks from a morphological standpoint instead of a biological or agronomical one, as has been done in the past. To begin, I performed puncture tests on a sample of 1000 dried cornstalks. To perform the tests, each stalk was loaded into a universal testing machine which had been fitted with custom attachments, including one to support each stalk and one which acted as a puncture probe. This probe had a 2-mm diameter and a 45 degree chamfer at the tip. The stalks were loaded in the same manner each time, with the minor diameter axis parallel to the vertical. Next, a puncture test was performed on each internode of each stalk. After each puncture test, a force displacement graph was produced which gave information about the diameter and rind thickness of the stalk when examined properly. One such graph is displayed in figure 1. This information was used to calculate other valuable information about the morphology of each stalk, such as the moment of inertia and the section modulus, both of which give insight into the strength of a stalk.

These values (the moment of inertia and section modulus) were also weighted with the puncture resistance forces seen in the force displacement graph. This meant that the outside of each stalk, which has a strong, hard rind, would count more towards these values than the inside pith, which is soft and full of voids. After each value had been calculated using a customized MATLAB algorithm, correlations were made between the newly calculated values and the approximated strength of each stalk, which had been calculated in previous experiments.

Project Accomplishments:
This project accomplished many things. First, a table of data from the 1000 stalks was created, leaving a valuable wealth of information that can be examined for trends for years to come. Already, other ways of optimizing maize stalks are being examined using this data.

In addition to this, I was able to customize a MATLAB algorithm specifically for maize puncture tests. This should ensure that anyone wanting to process future data will be able to do so quickly and easily using the same setup. This is especially important because during my project, I had a chance to travel to the University of Kentucky and train other students in performing puncture tests. This collaboration will allow additional data to be collected and examined for further studies and confirmation of results.

The most significant result of this project was the strong correlation found between the force-weighted values that were calculated and the approximated strength values found in previous studies. Correlations were created for each value calculated from the MATLAB algorithm. These values are shown in table 1.

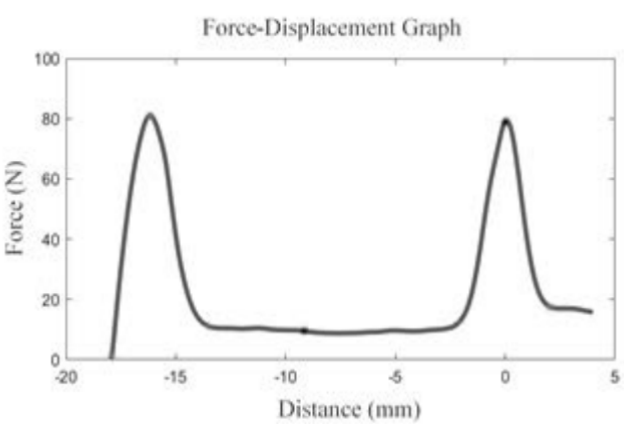


Figure 1: A force displacement graph from a puncture test. The peaks roughly indicate the entrance and exit of the probe, and the lower middle is the pith resistance.

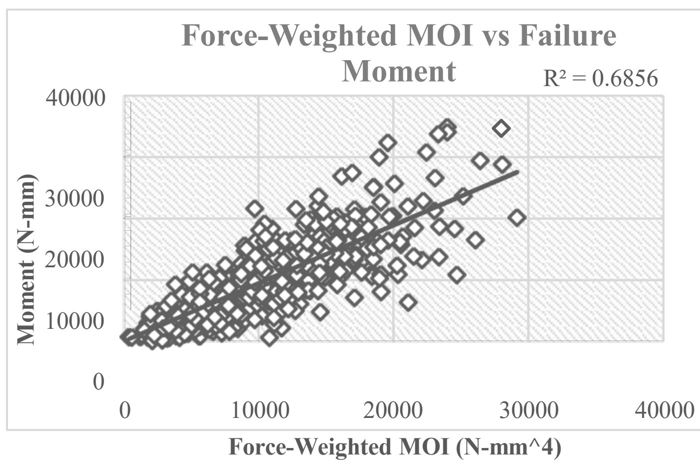


Figure 2: A graph of the puncture resistance weighted (force-weighted) moment of inertia vs the failure moment, which is an approximation of strength.

Table 1	Without Force-Weighting	With Force-Weighting
Section Modulus	0.2758	0.622
Moment of Inertia	0.258	0.686
Diameter	0.258	-

Table 1: A table of R-squared values for different correlations between stalk properties and stalk strength.

As can be seen in Table 1, the force-weighted values have a much better correlation with strength than the plain values. This information is extremely important. Puncture tests are much quicker and much less destructive to perform than other measurements of stalk strength, making them a more optimal option. Additionally, it might be possible to create a hand-held device to evaluate puncture resistance in the field instead of in a lab, which would make data collection quick, easy, and inexpensive.

Budget Expenditures

Round Trip to Lexington, KY	**558.00**
Hotel in Lexington	447.00
Total	**$1005.00**

This project required travel to Lexington, Kentucky, to complete a portion of the work. The entirety of the project budget was dedicated toward this travel. Dr. Robertson covered the project supplies and other project-associated costs through his own funding. The remaining funding for this SURF award covered the fellowship portion ($4,000) of my award.

Acknowledgment: I greatly appreciate the generous support provided by the State Board of Education in the form of a SURF award from the UI Office of Undergraduate Research. Without this support from the SBOE/HERC, I would not have been able to participate in this research. This has been a tremendous experience for me.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) - Summer 2019

Fellowship Recipient: Jennifer Smith, Animal Science, University of Idaho

Faculty Mentor: Dr. Jason Karl, Associate Professor, Dept. Forest, Rangeland, and Fire Sciences

Project Title: Wearable Technology for Cows: Applications for Virtual Fencing

Project Overview:
Managing the distribution of grazing animals is necessary for animal husbandry, effective land stewardship, and protecting sensitive and riparian lands. Virtual fencing is the idea where the negative reinforcement is worn by the animal rather than by restricting movement by wire and posts.

Virtual fencing pairs location-based communication technology with wireless fencing, such as that used in dog collars and invisible fencing, to control the distribution, location, and movement of livestock. Virtual fencing has the potential to significantly improve livestock management on open range and reduce the costs and impacts of physical fencing.

Virtual fencing can be deployed in an inclusion mode where animals are kept within a defined area for instance to graze residual crops or for rotational grazing within smaller pastures. Virtual fencing can also be used to exclude animals from riparian and other sensitive areas or achieve remote rotational grazing of pastures and ranges Virtual fencing will require a device that stays on the animal and does not negatively affect health and productivity.

Objectives:

1) Relationship between age, weight, and nose size of individual animals;
2) Best anatomical fit and least irritation to the animal by testing three shapes and sizes of nose pads;
3) Maximum weight to allow the device to remain in place on the animal for 1 month in a natural grazing setting.

This research facilitates designing technologies to study the application of virtual fencing and how it affects livestock which will ultimately contribute to a revolution in the way rangelands and riparian areas are managed and grazed.

Results:

Our results show that within the two age groups of cattle, primiparous yearling heifers and multiparous cows, there is little difference in nose size and shape among animals in the same age group. In addition, a spherical shape is a good starting point for a contact for the device and 40 grams of weight on the nose of a yearling heifer is too much for long term wear, while 110 grams appears to be less irritating to the mucosal tissues. Of the 20 yearling heifers that were used in the two (2) week device wearing study, seven (7) devices fell off; four (4) were 140 grams and three (3) were 110 grams. We know that we must create a finished working device of less than 110 grams.

Project Expenses:

Research Item	Amount
Hardware for nose clips *tubing, crimpers, plastic cement, tools, washers, etc.*	$ 242.84
3D Printer Filament	$ 168.99
Bluetooth locators for nose devices	$ 199.96
Poster Printing for ICUR	$ 75.00
Transportation	$ 313.00
SURF student fellowship	$4,000.00
Total spent	$ 4999.79

Acknowledgment:

I greatly appreciate the generous support provided by the State Board of Education/HERC in the form of a SURF award from the U of I Office of Undergraduate Research. This was an amazing experience for me. Without this support from the SBoE/HERC, I would not have been able to participate in this experience. Thank you.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) – Summer 2019

Fellowship Recipient: Kael Stelck, Chemical Engineering, University of Idaho

Faculty Mentor: Dr. Mark Roll, Associate Professor, Dept of Materials Science

Project Title: Nanoreactors: Production of a Catalytic Membrane via Organo-Trialkoxy-Silanes

Abstract: Porous materials have many current uses that are already in place in some of the biggest industries today. The adsorption properties of high surface area materials are well known and used in gold mining to get higher yields. However, using porous materials as nanoreactors is a current source of discovery. This project seeks to make mesoporous materials from organo-trialkoxy-silanes (RTOS) in order to make highly structured nanoreactors that can aide in forming highly aligned polymer fibers. The making of highly aligned polymer fibers can be done, but the mesoporous materials used in previous experiments are hard to replicate. Using RTOS in enhancing the surfactants used to create the mesoporous material has not yet be done. By creating a highly structured nanoreactors that can be more easily replicated will greatly assist future catalyst research.

Project Accomplishments

1. Determine method of easily synthesizing mesoporous silica material from tetraethyl orthosilicate (TEOS) with ionic surfactants.

   I used two different methods to create MCM-41 using ionic surfactants and TEOS. Both methods recommended cetyltrimethylammonium bromide (CTAB) as the ionic surfactant. The first method called for TEOS to be added to a basic solution of surfactant along with expanding agents. The total time for this method takes about 26 hours. The second method adds TEOS to an acidic solution of surfactant and takes a total time of about one hour.

   Results: The second method proved to be the quicker reaction and had a yield of 76%. The X-Ray Diffraction (XRD) also was shown to be more similar to MCM-41 when using the second method. Based upon both those factors I decided to move forward using the second method as a base for creating MCM-41.

2. Optimize surfactant removal via calcination and dissolution with ethanol.

   Using the method decided upon above I then attempted to remove the surfactant from the MCM-41 after the solid product had formed and been filtered out. Calcination at 550°C removes all the surfactant by oxidation. However, by oxidizing the surfactant, it all is destroyed. This would make any large-scale application potentially costly. Surfactant removal via dissolution with ethanol was used as the surfactant can then be recovered.

   Results: By using dissolution with ethanol to remove the surfactant 72% of the surfactant added to the reaction was recovered.

3. Analyze XRD and Thermogravimetric Analysis (TGA) of silica products.

XRD was used to determine the ordering of the mesoporous silica products. TGA was used to determine mass reduction during surfactant removal via calcination.

Results: XRD of MCM-41 products made by the method suggested in 1 proved that it was MCM-41 material. However, XRD of the MCM-41 after surfactant removal by either calcination or dissolution showed a breakdown in the MCM-41 structure. TGA data showed that the solid product before surfactant removal was about 58% silica oxide.

4. Explore hydrothermal treatment as a method to prevent MCM-41 structure decomposition during Surfactant removal.

   The breakdown of the MCM-41 structure during surfactant removal showed that the method being used to create the material was not adequate. By introducing hydrothermal treatment, we hope to prevent the breakdown. Currently, experiments with hydrothermal treatments with varying temperature and time are being conducted to determine which is best for the preservation of the MCM-41 structure after the removal of the surfactant.

5. Synthesize ionic surfactants for future use in Nano-ordering mesoporous silica.

   For future research it is important that many types of surfactants are experimented with. By combining and alkyl halide with an alkyl chain of 16 carbons to a tertiary amine a quaternary ammonium salt can be made. These types of surfactants like CTAB are ionic. Currently products are made, but still need to be purified and analyzed. More still need to be synthesized.

Summary of Expenditures:

Supplies	**Cost**
Chemstores: Consumables, Safety supplies	$104.42
Matrix Scientific: Cetyltrimethoxy silane	$46.41
Fisher Sci.: Silane and Surfactants/Ligands	$228.65
Sigma Aldrich: Silicon Tetrachloride	$63.05
AK Scientific: Silica and surfactant precursors	$240.45
Sigma Aldrich: Colloidal silica and surfactants	$269.12
Surplus optical polarizing filter	$47.90
SURF Stipend	$4000
Total	$5,000.00

Conference Presentations: I with be presenting a poster of my research in April 2020 at the UI Undergraduate Research Symposium, and I have already presented a poster at the Idaho Conference on Undergraduate Research (ICUR) in Boise during July 2019.

Acknowledgements: I truly appreciate the generous support of the State Board of Education in the form of a Summer Undergraduate Research Fellowship. The experience I gained during this was invaluable. With this support from the State Board of Education, I would not have been able to participate in this research.

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) – Summer 2019

Fellowship Recipient: Isabell Strawn, Department of Biological Engineering

Faculty Mentor: Dr. James Moberly, Department of Chemical and Materials Engineering

Project Title: Development of a Protocol to Measure Viability of Microorganisms Encapsulated Within Polymer Hydrogel

Abstract:

Trichloroethylene (TCE), a commonly used industrial solvent, is a widespread, persistent, and carcinogenic groundwater pollutant. An effective treatment strategy for TCE contamination is bioremediation using reductively dechlorinating bacteria. However, during bioremediation changing pH levels can harm these degrading microbes. By incorporating the microbes into a polymer matrix, local pH gradients can be controlled, and the microbes are protected. This study assessed the viability of model microorganisms (*Lactobacillus casei* and *Lactobacillus acidophilus*) in various compositions and molecular weights of polyvinyl alcohol (PVA) and sodium alginate (SA) hydrogels. A method to measure viability of bacteria cells in biobeads was developed and evaluated. Viability was characterized using plate counts and optical density measurements. Preliminary data indicates increased viability in beads composed of higher molecular weight PVA. A second goal of the project was to determine if polymer modifications influence diffusion rates. Similarly sized ionic (methylene blue, metanil yellow) and neutral (caffeine) model compounds were used to investigate the effect of charge on diffusion. Diffusion of caffeine through hydrogel membranes was determined to be 40% slower in hydrogels containing bacterial cells than without biomass. Determination of encapsulated microbe viability assists in optimization of polymer formulations to better protect microbial consortia and improve degradation of contaminants.

Project Accomplishments:

The initial goal of this project was to assess the viability of microorganisms within hydrogels of various polymer compositions and molecular weights. This project developed methodology for conducting viability tests with biobeads. Several procedures were proposed, tested, and modified to optimize bacteria survival rates and to most accurately depict the viability of the microorganisms during the polymer formation step. The best procedure developed (detailed in **Figure 1**) was used to characterize the viability of bacteria in 10% PVA (of three different molecular weights)/2% SA beads and the viability of the cells in 4% SA biobeads. The results indicate that the bead composition most

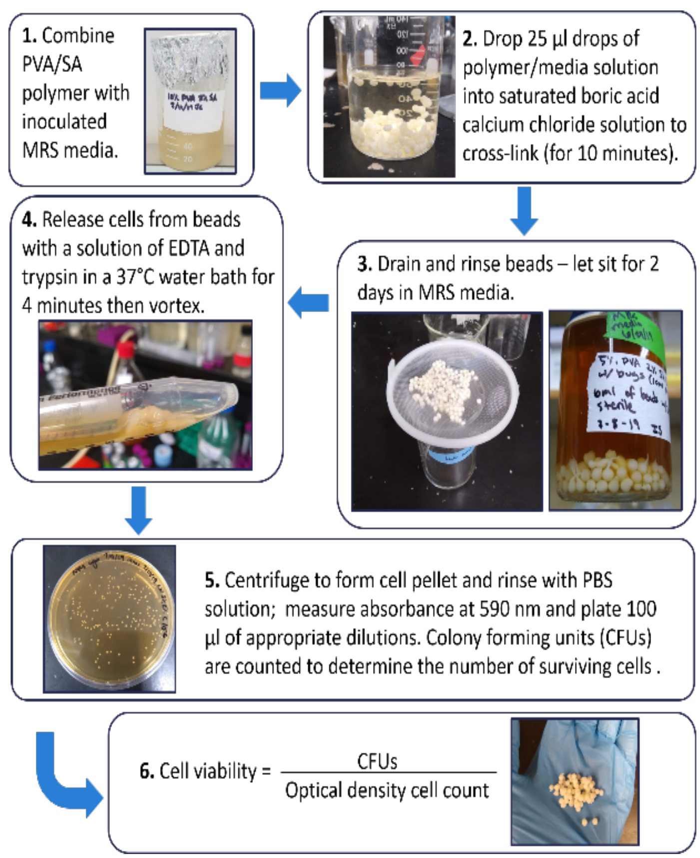


Figure 1. *The procedure to determine the viability of* L. casei *in polymer hydrogel biobeads.*

conducive to cell survival of those tested is 10% PVA (MW 146,000-186,000)/2% SA beads. Though the procedure worked sufficiently, future work will include further modifications to the viability testing process as well as testing of more polymer combinations. Characterizing the viability of microorganisms within the polymer hydrogels is a critical first step towards implementing this technology to improve bioremediation processes for TCE contaminated sites.

The second goal of this project was to investigate the diffusion properties of the polymer hydrogel, and this was accomplished by investigating the diffusion of three similarly sized neutral (caffeine) and ionic (metanil yellow and methylene blue) compounds through polymer pucks. These compounds were selected to quantify different electrostatic versus size filtering interactions with the polymers. Caffeine diffused the fastest, while diffusion of the charged compounds was substantially slowed, presumably due to electrostatic interactions with the polymers (**Figure 2**). Understanding reactions and interactions of molecules with the polymer hydrogels helps in optimization of the biobead size and polymer combinations to best accommodate the microorganisms and most efficiently degrade contaminants.

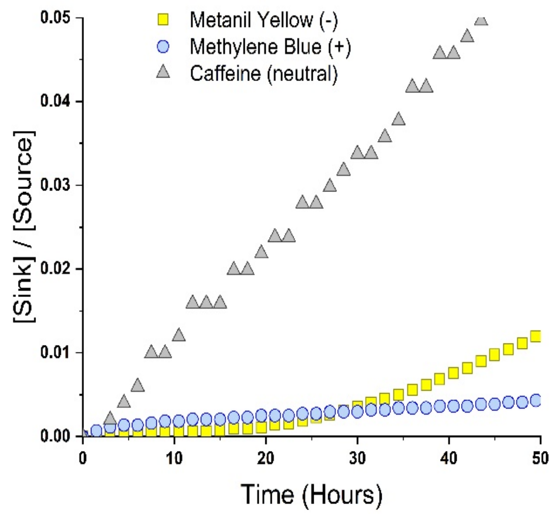


Figure 2. *Diffusion of metanil yellow, methylene blue, and caffeine in 10%PVA/2%SA hydrogel versus time.*

Summary of Budget Expenditures:

SURF Stipend	$4,000
Materials and Supplies IPTG ($299/5g), X-Gal ($199/100mg), lab coat ($24/each), consumables ~$400 (gloves, pipet tips, hydrogel polymer, plasticware)	$ 924
Other Expenses Poster printing for the UI Undergraduate Research Symposium ($75)	$75
Total	$ 4,999

Conference Presentation:
I presented a poster of my work at the 2019 Idaho Conference on Undergraduate Research (ICUR) in Boise, and I plan to present my research at the UI Undergraduate Research Symposium in April 2020.

Acknowledgement:
I truly appreciate the generous support provided by the State Board of Education in the form of a Summer Undergraduate Research Fellowship. This was a tremendous experience for me. Thank you for making this possible!

Final Project Report: Summer Undergraduate Research Fellowship (SURF) - Summer 2019

Fellowship recipient: Silpa Subedi, Biological Engineering, University of Idaho

Faculty mentor: Dr. Ching-An Peng, Department of Biological Engineering

Project Title: Engineering Nano Carriers for effective gene delivery in T cells

Abstract: Immunotherapy is a therapy that uses the power of our body's own immune system to find and destroy cancer cells. With the rapid development of nanotechnology in the recent decade, novel gene delivery in T cells is being studied to replace the expensive viral vectors in immunotherapy. In this study, calcium-alginate nanoparticles were synthesized with water-in-oil emulsion method using a tip-sonicator. The obtained size and morphology of the nanoparticles were observed to be varied with volume and concentration of sodium alginate, and surfactant used. To examine the potency of Ca-alginate nanoparticles as carriers for gene delivery in human cells, GFP-encoding plasmids were encapsulated in these nanoparticles. The transfection rate was then investigated in A549 cells, Mesenchymal stem cells and Jurkat T cells. Our results showed that Ca-alginate nanoparticles with an average size of 200 nm in diameter were capable for delivering gene in A549 cells and Mesenchymal Stem cells. We have not observed any gene delivery in T cells.

Project Accomplishments

1. One of my goals was to synthesize the nanoparticle with the average size of 150 nm

Alginate nanoparticles in this study were developed with water in oil emulsion method using a tip sonicator. The nanoparticles were formed by calcium crosslinking of guluronic acid units of alginate polymer where dichloromethane was used as the oil phase. To get an accurate size of around 150 nm, the nanoparticles were synthesized using different volume and concentration of sodium alginate and surfactant. The alginate nanoparticles were collected by ultracentrifugation and then characterized by measuring its size and charge by a zeta potentiometer.

Result- The average size of nanoparticle characterized by zeta potentiometer was 200 nm. As expected, the size of Ca-alginate nanoparticles decreased with the decrease in the volume and concentration of sodium alginate and surfactant used.

2. To investigate the transfection rate of synthesized calcium alginate nanoparticles in A549 cells, mesenchymal stem cells and Jurkat T cells the nanoparticles were capsulated with GFP-encoding plasmids.

In a 2-well cell culture plates A549 cells, MSC and Jurkat T cells were allowed to adhere at 37 °C overnight. The alginate nanocarriers were suspended in DMEM and was added directly to the cells. Alginate nanoparticles were incubated with the cells for 12 hours at 37 °C. Transfection efficacy in these cells were evaluated by measuring the percentage of cells expressing the exogenously delivered GFP in fluorescence microscope.

Result-The gene delivery in A549 cells and MSC were more efficient than T cells, because MSC and A549 cells grow as a monolayer, attaching to the culture flask T cells are suspension cells; that grow by floating in the cell culture medium.

Future Work

A CAR-gene capsulated nanoparticle will be synthesized and test its ability for effective gene delivery in T cells. The CAR-T generated from the project will be further tested for its ability to recognize tumor cells among healthy cells *in-vitro*.

Summary of Budget Expenditure

Supplies	Cost
Jurkat T cell line	$385
Cell culture medium	$200
Materials for Ca-alginate nanoparticles	$200
T-flasks and 6-well plates	$140
Poster	$75
Sub Total Supplies:	$1000
Stipend	$4000
Total	$5000

Conference Presentations: I have already presented a poster at 2019 Idaho Conference on Undergraduate Research (ICUR) in Boise. I will be presenting a poster of my work at the Undergraduate Research Symposium 2020.

Acknowledgement: I appreciate the generous support provided by the State Board of Education in the form of a Summer Undergraduate Research Fellowship. It was a great experience to work on my own research and to get exposure in a research environment. I am very much thankful to SOBE for providing me with this opportunity.

Final Project report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) - Summer 2019

Fellowship Recipient: Bishal Thapa, Biological Engineering, University of Idaho

Faculty Mentor: Dr. Xiao Wu, Professor, Department of Biological Engineering

Project Title: Fertilizer Production from Air and Water by An In-Liquid Electric Discharge Process

Abstract:
With the growing interest in sustainable farming, many eco-friendly alternative methods to produce plant accessible nitrogen is being studied. The aim of our research was to explore the feasibility of the fixation of nitrogen into NO3– and NO2– ions using a novel electrical discharge process (EDP) for producing a green fertilizer out of the air, water and electricity as input. At the discharge point in the EDP reactor, nitrogen and oxygen molecules dissociate into various reactive radicals and recombine into stable oxidative ions of NO3– and NO2– as the plasma discharge takes place. With a fixed air flow rate of 0.8 L/min, the concentration of NO3– and NO2– were profiled at different applied power levels for a batch of 300 ml water circulating through the EDP reactor for treatment. It was found that the concentration of NO3– increased with the increase in power and time of treatment. However, the NO2– concentration stably increased at lower power levels and decreased significantly at higher power. At 235 watts (W), the concentration of NO2– increased from 0.571 mg/l to 19.1 mg/l within 32 min. Similarly, the concentration of NO3– increased from 0.031mg/l to 84.6mg/l at the same operational conditions. When the power was increased to 358W, the concentration of NO2– increased from 0.005 mg/l to 17.8 mg/l in 16 minutes then it decreased to 0.019 mg/l by the end of 32 minutes, with NO3– increased from 0.114 mg/l to 266mg/l. At 417W, the concentration of NO2– fluctuated at a low level but the NO3– elevated from 0.354mg/l to 241 mg/l in the 32-minute period. This technology could be potentially developed for large scale production of nitrate fertilizer.

Project Accomplishments:
Objective 1: Study the effect of air flow rate on NOx production

In our previous preliminary experiments, we used 1-slpm as our input. So, one of the objectives of this research was to experiment with different air flow and understand its effect. For this experiment we added mass flow meter to our experimental setup to achieve consistent air flow.

Result: We found out that the production of NOx ions increases with the increase in air flow rate. But at high flow rate, if water circulation is not enough then burning occurs. The highest concentration we achieved at 100slpm water flow rate is 815gm/liter.

Objective 2: Study the effect of water flow rate on NOx production

To understand the effect of water circulation we are still conducting more experiment with multiple liquid flow rate. Since our system design did not withstand higher liquid pressure, necessary changes are recommended and are being made. As of now we are inconclusive of the effect of the liquid flow rate of NOx production.

Result: I will volunteer to complete experiments regarding effect of liquid flow rate during fall and I expect that with increasing flow rate the production increases.

Finally, after the completion of second objective, I will determine the optimum flow rate for production of NOx using plasma reactor.

Summary of Budget Expenditures

Description	Cost
4 boxes of Nitrate TNTplus Test Vials (0.2-13.5 mg/L NO3-N)	$188
4 boxes of Nitrite TNTplus Test Vials (0.6-6.0 mg/L NO2-N)	$162
4 boxes of Nitrate TNTplus Test Vials (5-35 mg/L NO3-N)	$188
4 boxes of Nitrite TNTplus Test Vials (0.015-0.600 mg/L NO2-N)	$162
6x customized quartz dielectric plates	$225
UI Symposium Poster	$75
SURF Stipend	$4,000
Total	**$5,000**

Conference Presentation: I had a time conflict which prevented me from attending and presenting my work at ICUR this year. However, I presented my research in Annual meeting of American Society for Agricultural and Biological Engineers on June 9^{th} in Boston Massachusetts. I will also be presenting my research at UI undergraduate Research Symposium in Spring of 2020.

Acknowledgement: Summer Undergraduate Research Fellowship has helped me grow professionally and academically. With this experience, I feel confident on building a reactor for my future research, and now have the experience to plan the entire research project and execute it. I am very grateful for the generous support provided by Idaho State Board of Education through Summer Undergraduate Research Fellowship. Without the support of SBOE, I would not have been able to conduct such rigorous research project. I also thank Dr. Pfeiffer and the Office of Undergraduate Research for making this possible!

Final Project Report: Office of Undergraduate Research (OUR) Summer Undergraduate Research Fellowship (SURF) - Summer 2019

Fellowship Recipient: Eric Vallin, Biological Sciences, University of Idaho

Faculty member: Dr. Katy Brown, Associate Professor, Department of Human Sciences

Project Title: Low Energy Availability and Resting Metabolic Rate in Non-athlete College Males

Abstract:
Low energy availability (LEA) results in low bone mineral density, hormonal changes, and menstrual dysfunction in females. This has been extensively studied in female athletes and is known as the Female Athlete Triad. Studies have shown a link between low energy availability and a low resting metabolic rate. Low energy availability is scarcely studied among the male demographic and minutely studied in sedentary populations. The aim of this study was to assess the relation between LEA and resting metabolic rate in college-aged non-athlete males. 19 participants completed this portion of the study and we've found no correlation between resting metabolic rate and energy availability (r_s= .184, p=.450). However, we did find a correlation between lean body mass and RMR (r_s=.570, p<0.001).

Project Objectives and Accomplishments:

1. To establish and confirm a correlation between body mass and resting metabolic rate.

Upon doing our research we found a correlation between lean body mass and resting metabolic rate. Resting metabolic rate was taken with a "Body Gem" indirect calorimeter right after waking, with zero food or drink 8 hours prior to the test. This machine measures your resting metabolic rate, which is how many calories your body burns in a day completely at rest. It does this to obtain and continue equilibrium and regular physiological functioning. Muscle tissue requires a lot more energy to obtain and continue to have. Muscle cells are very active physiologically. So when we found that the males with more lean body mass (muscle), had a higher RMR- (r_s=.570, p<0.001), it confirmed my hypothesis.

2. Determine the relationship between Energy Availability and Resting Metabolic rate.
My hypothesis was that if an individual had low energy availability, it would mean their body would have to operate at a lower RMR (lower caloric intake= lower energy surplus). Although this was determined and confirmed true in female populations with the female athlete triad, it was not true for the males in our study. We found no correlation between the two - (r_s= .184, p=.450).

Summary for Budget Expenditures:
- RMR testing supplies: $11.96 per participant x 40 participants = $478.4
- DXA scan = $10.54 per participant x 40 participants = $421.6
- Incentive (drawing for 4, $25 Amazon gift cards) = $100
  SURF Stipend = $4,000
- **Total = $5,000**
- *Poster printing covered by FCS Department = $0

Acknowledgement: I am very grateful for the people on the State Board of Education that allowed me the funds to pursue research such as this. It was the first time I was able to take my scientific curiosity and scientific self to new heights. I am very happy to have done such amazing work with my fellow peers and professors. Thank you to the U of I Office of Undergraduate Research for facilitating this!

Idaho State University 2019 Undergraduate Research Report

The Office for Research would like to thank the Idaho State Board of Education Higher Education Research Council for the Strategic Initiative Undergraduate Research funding for $55,000 that we received.

The funding was a very successful in growing our Undergraduate Research in the STEM fields.

With these funds, we were able to support 10 research projects and help support 19 students in traveling to professional conferences.

The students have been very vocal in expressing their appreciation for the financial support and mentoring that has given them an opportunity to experience research and grow their knowledge of conducting research in higher education. Many of them have expressed that they will be continuing their education and seeking a Masters or PhD in a STEM field.

When students participate in an opportunity such as these funds have provided it is quite the thing to see them grow in education, skills, and confidence.

The student posters and individual reports have been compiled in a Box file that have been shared with you.

Idaho State University 2019 Undergraduate Research Report

Idaho State University Office for Research would like to thank the Idaho State Board of Education for the additional $32,000 in Strategic Initiative Undergraduate funding. This funding has enabled us to increase our Undergraduate Research activity and enhance our undergraduate research mentoring program. Students were required to complete an application that outlined their academic goals and how they expected to benefit from the funds. In addition, the Office for Research saw this as an opportunity to LISTEN to our undergraduate students and learn what they thought about research. We included a page with the application with questions about mentoring and research. We will use the answers to help us improve our Undergraduate mentoring program.

Our Undergraduate research students have continually showed their appreciation for the opportunity to participate in Undergraduate research and have told us how their research experience has changed their lives.

This enhanced terms and conditions allowed us to distribute these funds a bit differently. We were able to support our Department of Biology by awarding them $17,000 for their Undergraduate Research faculty and students. The $17,000 supported 15 faculty in undergraduate research projects, 18 Undergraduate students that are pursuing a degree in Biological Sciences.

One student utilized $1,000 of these funds to assist in hosting the first Psi Chi Psychology conference here at Idaho State University. These funds were a huge benefit to our Undergraduate students who would not have the funding to travel to a regional conference in a neighboring state. While bringing a diversity of attendees for our Undergraduate students to have the opportunity to network with, it also puts ISU and our Undergraduate research in Psychology program in the spotlight. Undergraduate students from other universities have been able to see and experience our university, our Undergraduate research students, faculty, and Psychology programs.

With these funds, we also awarded six undergraduate research students funding to attend and present at a conference and funded another five Undergraduate research projects.

The students' reports and copies of posters are available on Box in a file that will be shared with Dr. Cathleen McHugh.

Lewis and Clark State College - 2019 Undergraduate Research Funding Report

Undergraduate Research Projects						
Student Name	**Advisor**	**Project**	**Semester or Year long**	**Travel**	**Salary**	**Total**
Kory Parker	Jacob Hornby	Multi-drug resistant Candida auris	Year	$ -	$ 3,840.00	$ 3,840.00
Janice Aylward	Matt Brady	Urban noise and song birds	year	$ -	$ 1,000.00	$ 1,000.00
Ashley Hays	Matt Brady	Urban noise and song birds	year	$ 243.00	$ 1,000.00	$ 1,243.00
Rayanna Grove	Mike Edgehouse	Snake head morphology	year	$ -	$ 1,040.00	$ 1,040.00
Ethan Crane	Leigh Latta	Phonon vibrations and *Daphnia*	year	$ -	$ 1,000.00	$ 1,000.00
Rhegan McGregor	Leigh Latta/Nancy Johnston	Antimicrobial Arborvitae	year	$ -	$ 2,100.00	$ 2,100.00
Robert Roth	Mike Edgehouse	Genetics and snake head morphology	year	$ -	$ 1,040.00	$ 1,040.00
Tristan Olsen	Heather Moon	Data Analytics	year	$ -	$ 3,200.00	$ 3,200.00
Rachel Sila	Heather Moon	Image Analysis algorithm	year	$ -	$ 3,200.00	$ 3,200.00
Laurel Nunez	Nancy Johnston	Atmospheric Benzene	semester	$ -	$ 2,400.00	$ 2,400.00
Phillip Scott	Nancy Johnston	Air/Water VOCs	year	$ -	$ 1,960.00	$ 1,960.00
DeLaney Jones	Seth Long	Computer Assisted Seg tool	semester	$ -	$ 1,400.00	$ 1,400.00
Rhiana Fox	Heather Moon	NPO and Data Analytics	year	$ -	$ 3,200.00	$ 3,200.00
Jared Simons	Charles Addo-Quaye	DNA damage and mutation errors	semester	$ -	$ 1,600.00	$ 1,600.00
					SUB-TOTAL	**$ 28,223.00**
HERC Supplemental Funds [used to develop research modules in courses]						
Faculty/ TA name	**Advisor**	**Project**	**Semester or Year long**	**Travel**	**Salary + fringe**	**Total**
Heather Moon	Math 386	develop research module for Modern Geometry	semester	$ -	$ 1,815.00	$ 1,815.00
Jenni Light	GIS 481	develop research module for Digital Remote Sensing	semester	$ -	$ 1,815.00	$ 1,815.00
Eric Stoffregen	BIOL 341	develop research module Genetics	semester	$ -	$ 1,815.00	$ 1,815.00
Seth Long	BIOF 350	develop research module Image Analysis	semester	$ -	$ 1,815.00	$ 1,815.00
					SUB-TOTAL	**$ 7,260.00**
					TOTAL	**$ 35,483.00**

Final Report for HERC Funding for the 2019 Idaho Conference on Undergraduate Research (ICUR)
Submitted by Donna Llewellyn, Executive Director of the Boise State Institute for STEM and Diversity Initiatives

ICUR 2018 was held on July 30 and 31, 2019 at Boise State University. The total attendance was 422 (not counting some who only came to see the poster sessions), from 48 different institutions/organizations. This included 276 students with 204 poster presentations, and 146 faculty, industry, and governmental representatives. We are very pleased that we had a great increase in participation over the 2018 conference, especially given that this year we unfortunately conflicted with the statewide INBRE conference. 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 full days of workshops and presentations – see the following pages for the program schedule. With the added support from HERC, we added a reception held in the Stueckle Sky Center honoring all of the research mentors. More details are also available at
https://www.boisestate.edu/stem-icur/
A pdf version of the printed program that was handed out at the event is available upon request.

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.

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

Item	Amount
Catering	$15,474.20
Program Design and Printing	$4098.56
Invited Speaker Hotel and Travel	$733.50
Facilities and Events	$3164.58
Materials and Supplies	$493.06
Admin, Evaluation, and Director Support	$8,036.10
TOTAL	**$32,000**

Other support for the conference came from a number of grant programs at Boise State University, the Institute for STEM and Diversity Initiatives, the University of Idaho, Idaho State University, the Idaho STEM Action Center, and the Idaho NSF EPSCoR Track I Grant (GEM3).

ICUR 2019 PROGRAM

ALL SESSIONS ARE ON THE SECOND FLOOR OF THE STUDENT UNION BUILDING UNLESS OTHERWISE NOTED

TIMES	TUESDAY, JULY 30	
8:00 AM	**REGISTRATION OPENS:** Simplot Ballroom Lobby **POSTER SET-UP/ CONTINENTAL BREAKFAST:** Simplot Ballroom	
9:00 – 9:30 AM	**OPENING CEREMONY:** **Angela Hemingway**, Idaho STEM Action Center **Location:** Special Events Center (SUB First Floor)	
9:30 – 10:30 AM	**PLENARY SPEAKER:** **Connie Miller**, ICON **TITLE:** **SETTING YOUR CAREER UP FOR SUCCESS** **Location:** Special Events Center (SUB First Floor)	
10:30 – 10:45 AM	**BREAK**	
10:45 – 11:45 AM	**REUS (RESEARCH EXPERIENCE FOR UNDERGRADUATES)** **Facilitator:** **Rick Ubic**, Boise State University **Speakers:** **Panel Discussion** **Location:** Lookout Room	**HOW TO GET CONNECTED TO MAKE A DIFFERENCE** **Speaker** **Tammy de Weerd**, Mayor of Meridian **Location:** Bishop Barnwell Room
11:45 AM – 1:45 PM 11:45 AM – 12:45 PM 12:45 PM – 1:45 PM	**POSTER PRESENTATIONS AND BUFFET LUNCH** **Location:** Simplot Ballroom **Odd numbered posters** **Even numbered posters**	
1:45 – 2:00 PM	**BREAK**	
2:00 – 3:00 PM	**FACULTY RESEARCH LIGHTNING TALKS** **Moderator:** **Greg Martinez**, Boise State University **Speakers:** **Jill AnnieMargaret**, Boise State University **Jonathan Counts**, University of Idaho **John Dudgeon**, Idaho State University **Alejandro Flores**, Boise State University **Sara Getz**, Idaho State University **Eric Jankowski**, Boise State University **Location:** Lookout Room	**FUNDING GRADUATE SCHOOL** **Speaker:** **Liljana Babinkostova**, Boise State University **Panel of students** **Location:** Bishop Barnwell Room
3:00– 3:15 PM	**BREAK**	
3:15 – 4:15 PM	**STUDENT RESEARCH LIGHTNING TALKS** **Moderator:** **Deb Easterly**, Idaho State University **Speakers:** **Mia Cinello-Smith**, College of Western Idaho **Andrew Dimmick**, Idaho State University **Alexandra Flores**, University of Idaho **Azhar Koshkimbayeva**, College of Idaho **Kayla Munkres**, Boise State University **Sam Roth**, Northwest Nazarene University **Jared Simons**, Lewis-Clark State University **Location:** Lookout Room	**GETTING INTO GRADUATE SCHOOL** **Moderator:** **Claire Harrigan**, Boise State University **Panel of current graduate students** **Location:** Bishop Barnwell Room
4:15 - 5:15 PM	**OVERCOMING IMPOSTER SYNDROME AND AND STEREOTYPE THREAT** **Speaker:** **Barbara Wood Roberts**, Idaho State University **Location:** Lookout Room	**ETHICS IN RESEARCH** **Speaker:** **Aleta Quinn**, University of Idaho **Location:** Bishop Barnwell Room
6:00 PM	**RECEPTION AT STUECKLE SKY CENTER – DOUBLE R RANCH ROOM** **Emcee:** **Michal Temkin Martínez**, Boise State University **Speakers:** **Mustafa Mashal**, Idaho State University **Mahesh Acharya**, Idaho State University student **Jordan Hawley**, University of Idaho student **Claire Oberg**, Boise State University student	

ICUR 2019 PROGRAM

ALL SESSIONS ARE ON THE SECOND FLOOR OF THE STUDENT UNION BUILDING UNLESS OTHERWISE NOTED

TIMES	WEDNESDAY, JULY 31
8:00 AM	**REGISTRATION:** Simplot Ballroom Lobby **POSTER SET-UP/CONTINENTAL BREAKFAST:** Simplot Ballroom
9:00 - 10:00 AM	**PLENARY SPEAKER:** **Marianne Walck**, Idaho National Laboratory **TITLE:** **RESEARCH AT INL: MOVING THE NATION TOWARD A NEW ENERGY FUTURE** **Location:** Special Events Center (SUB First Floor)
10:00 - 10:15 AM	**BREAK**
10:15 - 11:30 AM	**STUDENTS: TELLING YOUR STORY: COMMUNICATING YOUR RESEARCH TO THE PUBLIC** **Facilitator:** **Amy Ulappa**, Boise StateUniversity **Interactive Session** **Location:** Lookout Room **FACULTY: STRATEGIES FOR MENTORING STUDENTS FROM UNDERSERVED POPULATIONS** **Speaker:** Barbara Wood Roberts, Idaho State University **Location:** Bishop Barnwell Room
11:30 - 11:45 AM	**BREAK**
11:45 AM - 1:45 PM 11:45 AM - 12:45 PM 12:45 PM - 1:45 PM	**POSTER PRESENTATIONS AND BUFFET LUNCH** **Location:** Simplot Ballroom **Odd numbered posters** **Even numbered posters**
12:45 - 1:45 PM	***IDAHO DIVERSITY NETWORK MEETING (*BY INVITATION ONLY)** **Facilitator:** **Sarah Penney**, Idaho NSF EPSCoR **Location:** *Bishop Barnwell Room
1:45 - 2:00 PM	**BREAK**
2:00 - 3:15 PM	**RESEARCH TALKS — SOCIAL IMPACT OF RESEARCH: RESEARCH IN THE COMMUNITY** **Moderator:** **Annal Frenz**, Boise State University **Speakers:** **Kelly Hopping**, Boise State University **Kellee Kirkpatrick**, Idaho State University **Yvonne Nyavor**, University of Idaho **Location:** Lookout Room **WORKSHOP ON FAILURE AND RECOVERING FROM FAILURE** **Facilitator:** **Stephen Crowley**, Boise State University **Interactive Session** **Location:** Bishop Barnwell Room
3:15 PM	**CLOSING CEREMONY** **Speaker:** **Joshua Pak**, Idaho State University **Location:** Lookout Room
4:00 PM	**PLANNING COMMITTEE BUSINESS MEETING** **Location:** Foote Room

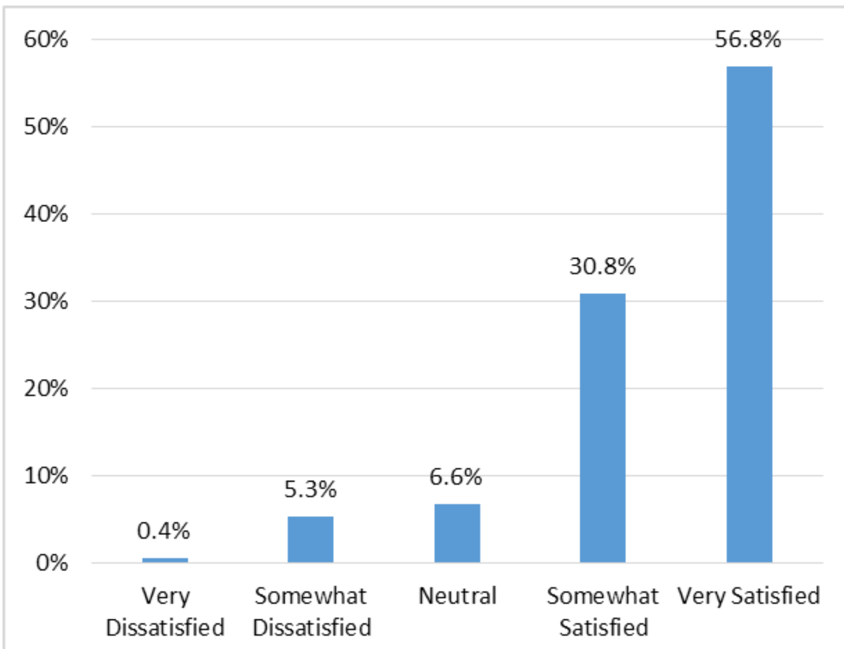
Idaho Conference on Undergraduate Research 2019
Preliminary Survey Results
October 2, 2019

RESPONSE RATE: 53.8%

- 422 attendees
  - 276 students
  - 146 faculty/staff/other

- 227 recorded responses
  - 224 completed surveys
  - 3 incomplete responses: All of these answered questions through, "Please select your role."

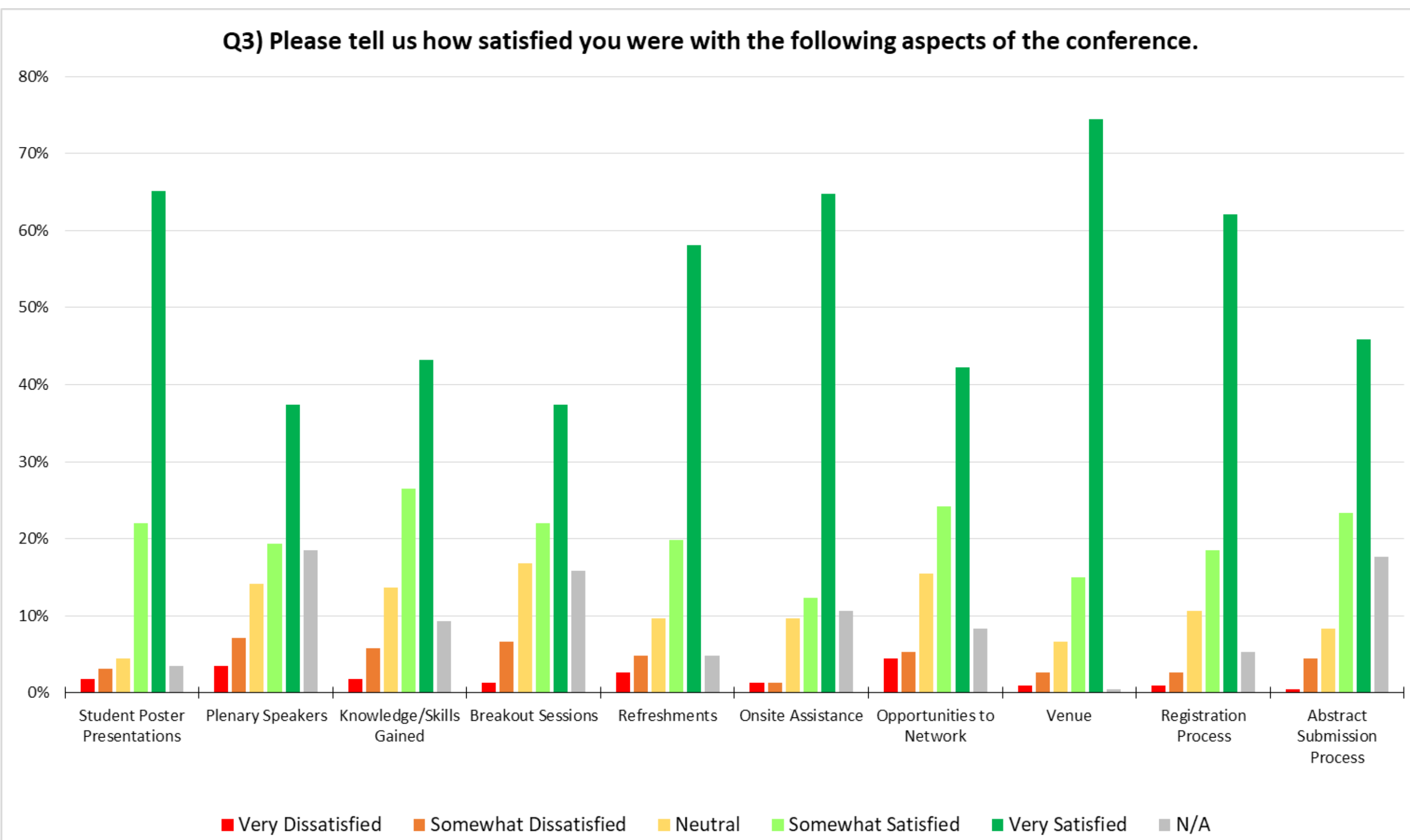
Q2) Please indicate your overall satisfaction with the 2019 Idaho Conference on Undergraduate Research.



Answer	%	Count
Very Dissatisfied	0.4%	1
Somewhat Dissatisfied	5.3%	12
Neutral	6.6%	15
Somewhat Satisfied	30.8%	70
Very Satisfied	56.8%	129
Total	100.0%	227

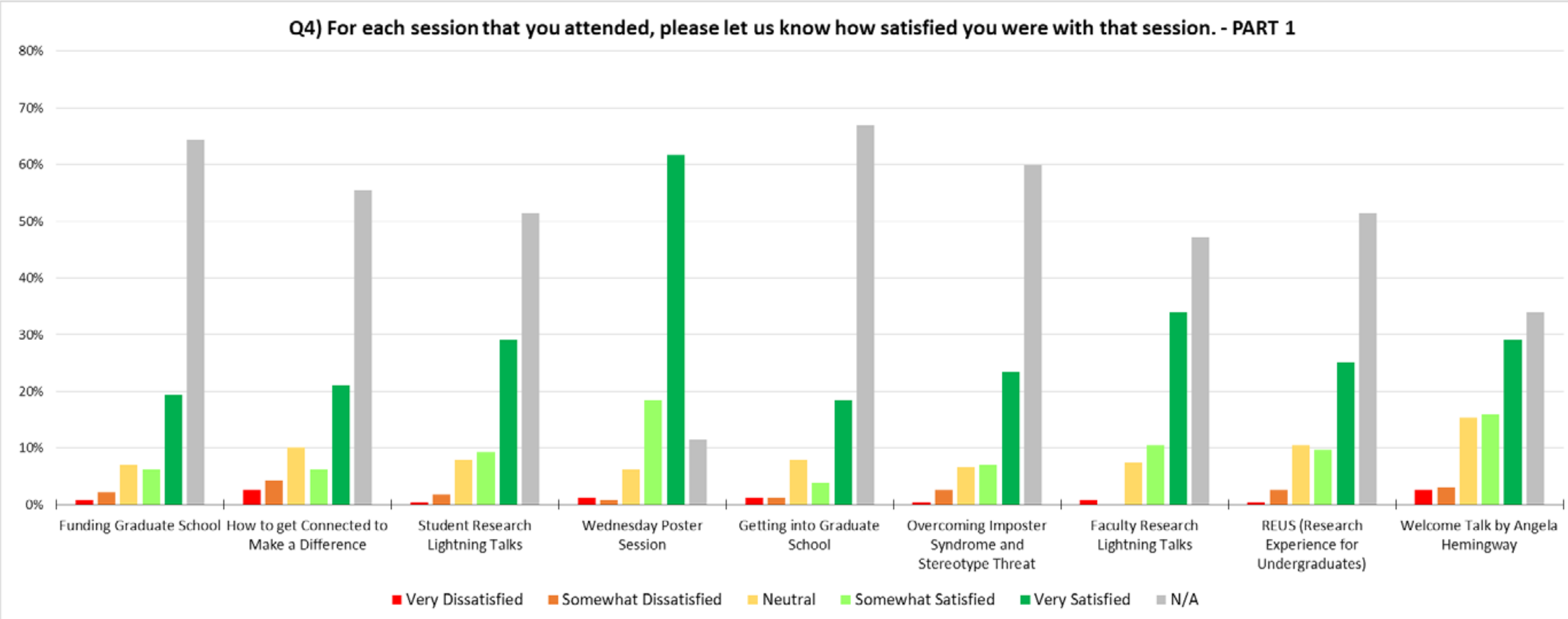
Q3) Please tell us how satisfied you were with the following aspects of the conference.

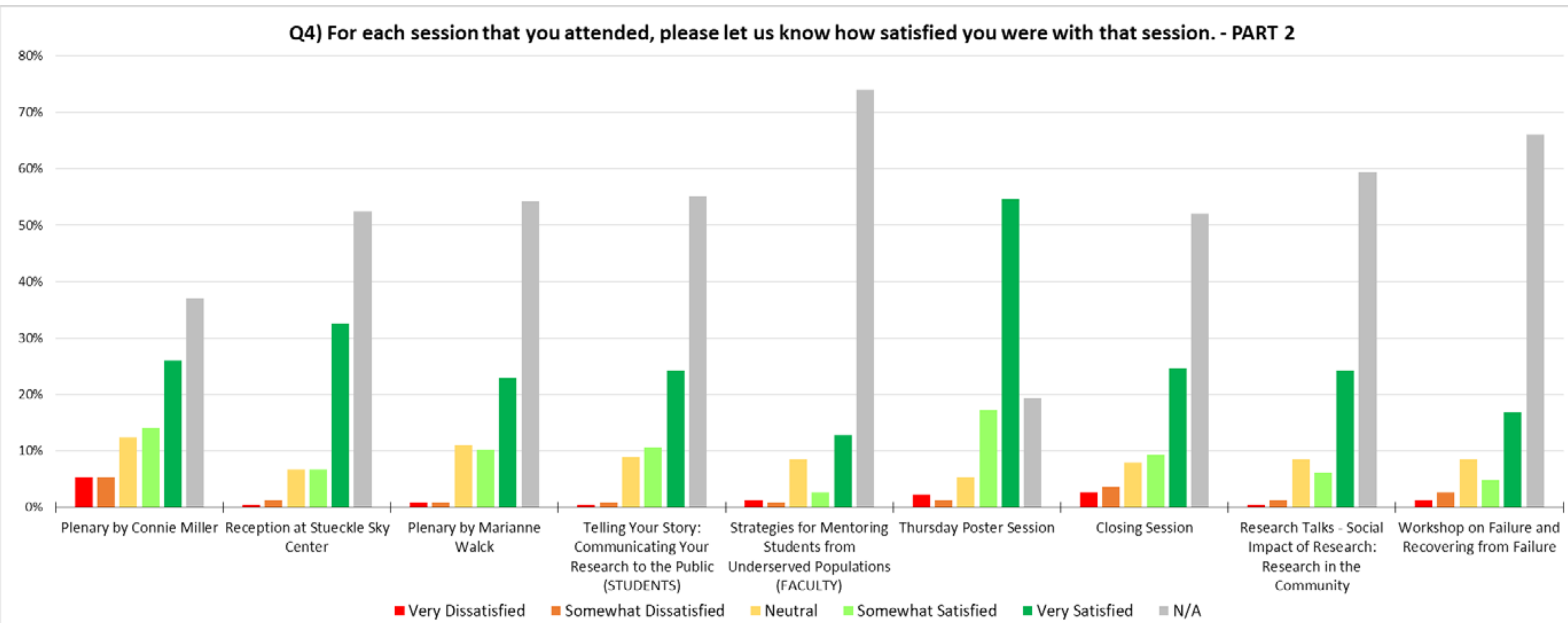
	Very Dissatisfied		Somewhat Dissatisfied		Neutral		Somewhat Satisfied		Very Satisfied		N/A		Total	
Aspect	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**
Student Poster Presentations	2%	4	3%	7	4%	10	22%	50	65%	148	4%	8	100%	227
Plenary Speakers	4%	8	7%	16	14%	32	19%	44	37%	85	19%	42	100%	227
Knowledge/Skills Gained	2%	4	6%	13	14%	31	26%	60	43%	98	9%	21	100%	227
Breakout Sessions	1%	3	7%	15	17%	38	22%	50	37%	85	16%	36	100%	227
Refreshments	3%	6	5%	11	10%	22	20%	45	58%	132	5%	11	100%	227
Onsite Assistance	1%	3	1%	3	10%	22	12%	28	65%	147	11%	24	100%	227
Opportunities to Network	4%	10	5%	12	15%	35	24%	55	42%	96	8%	19	100%	227
Venue	1%	2	3%	6	7%	15	15%	34	74%	169	0%	1	100%	227
Registration Process	1%	2	3%	6	11%	24	19%	42	62%	141	5%	12	100%	227
Abstract Submission Process	0%	1	4%	10	8%	19	23%	53	46%	104	18%	40	100%	227



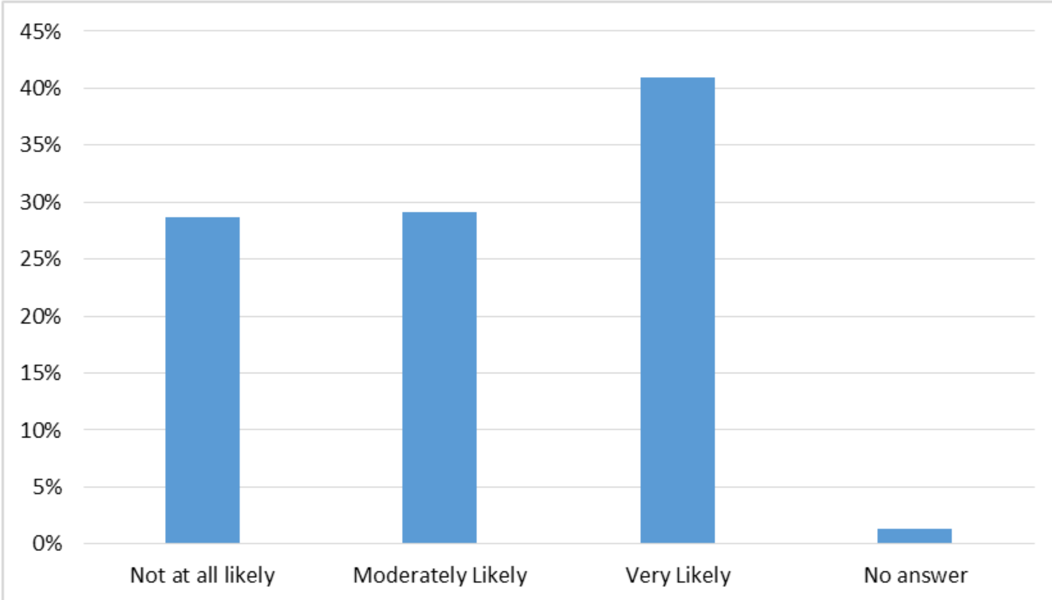
Q4) For each session that you attended, please let us know how satisfied you were with that session.

	Very Dissatisfied		Somewhat Dissatisfied		Neutral		Somewhat Satisfied		Very Satisfied		N/A		Total	
Session	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**
Funding Graduate School	1%	2	2%	5	7%	16	6%	14	19%	44	64%	146	100%	227
How to get Connected to Make a Difference	3%	6	4%	10	10%	23	6%	14	21%	48	56%	126	100%	227
Student Research Lightning Talks	0%	1	2%	4	8%	18	9%	21	29%	66	52%	117	100%	227
Wednesday Poster Session	1%	3	1%	2	6%	14	19%	42	62%	140	11%	26	100%	227
Getting into Graduate School	1%	3	1%	3	8%	18	4%	9	19%	42	67%	152	100%	227
Overcoming Imposter Syndrome and Stereotype Threat	0%	1	3%	6	7%	15	7%	16	23%	53	60%	136	100%	227
Faculty Research Lightning Talks	1%	2	0%	0	7%	17	11%	24	34%	77	47%	107	100%	227
REUS (Research Experience for Undergraduates)	0%	1	3%	6	11%	24	10%	22	25%	57	52%	117	100%	227
Welcome Talk by Angela Hemingway	3%	6	3%	7	15%	35	16%	36	29%	66	34%	77	100%	227
Plenary by Connie Miller	5%	12	5%	12	12%	28	14%	32	26%	59	37%	84	100%	227
Reception at Stueckle Sky Center	0%	1	1%	3	7%	15	7%	15	33%	74	52%	119	100%	227
Plenary by Marianne Walck	1%	2	1%	2	11%	25	10%	23	23%	52	54%	123	100%	227
Telling Your Story: Communicating Your Research to the Public (STUDENTS)	0%	1	1%	2	9%	20	11%	24	24%	55	55%	125	100%	227
Strategies for Mentoring Students from Underserved Populations (FACULTY)	1%	3	1%	2	8%	19	3%	6	13%	29	74%	168	100%	227
Thursday Poster Session	2%	5	1%	3	5%	12	17%	39	55%	124	19%	44	100%	227
Closing Session	3%	6	4%	8	8%	18	9%	21	25%	56	52%	118	100%	227
Research Talks - Social Impact of Research: Research in the Community	0%	1	1%	3	8%	19	6%	14	24%	55	59%	135	100%	227
Workshop on Failure and Recovering from Failure	1%	3	3%	6	8%	19	5%	11	17%	38	66%	150	100%	227


Q4) For each session that you attended, please let us know how satisfied you were with that session. - PART 1
80%
70%
60%
50%
40%
30%
20%
10%
0%
Funding Graduate School
How to get Connected to Make a Difference
Student Research Lightning Talks
Wednesday Poster Session
Getting into Graduate School
Overcoming Imposter Syndrome and Stereotype Threat
Faculty Research Lightning Talks
REUS (Research Experience for Undergraduates)
Welcome Talk by Angela Hemingway
Very Dissatisfied
Somewhat Dissatisfied
Neutral
Somewhat Satisfied
Very Satisfied
N/A


Q4) For each session that you attended, please let us know how satisfied you were with that session. - PART 2
80%
70%
60%
50%
40%
30%
20%
10%
0%
Plenary by Connie Miller
Reception at Stueckle Sky Center
Plenary by Marianne Walck
Telling Your Story: Communicating Your Research to the Public (STUDENTS)
Strategies for Mentoring Students from Underserved Populations (FACULTY)
Thursday Poster Session
Closing Session
Research Talks - Social Impact of Research: Research in the Community
Workshop on Failure and Recovering from Failure
Very Dissatisfied
Somewhat Dissatisfied
Neutral
Somewhat Satisfied
Very Satisfied
N/A

Q10) How likely are you to attend ICUR next year?



Answer	%	Count
Not at all likely	28.6%	65
Moderately Likely	29.1%	66
Very Likely	41.0%	93
No answer	1.3%	3
Total	100.0%	227

FY 2020 Allocation of HERC Funds

			FY2020 Proposed Allocation
		Total $4,163,200	
HERC IGEM			1,541,400
Infrastructure Funds			850,000
Matching Grants (EPSCoR Match)			800,000
Incubation Fund			224,670
Undergraduate Research			217,000
Administrative Costs			2,700
Total		**$3,635,770**	3,635,770
Balance			527,430
IGEM Funds			
BSU	IGEM 19-02		$666,500
ISU	IGEM 20-01		$0
UI	IGEM 19-01		$700,000
UI	IGEM 20-02		$174,900
LCSC			
Total IGEM			**$1,541,400**
Research Infrastructure Funds			$0
BSU			$250,000
ISU			$250,000
UI			$250,000
LCSC			$100,000
Total Infrastructure			**$850,000**
Matching Award Grants			
NSF-EPSCoR			$800,000
Total Matching Grants			**$800,000**
Targeted Research			
Idaho Incubation Fund (7th round)			
BSU			
Kandadai "Optical Sensors"			$75,000
Subbaraman "Ink Production"			$74,970
ISU			
UI			
Robsion "Darwin's Demons"			$74,700
Transfer in			
Total Targeted Research			**$224,670**
Undergraduate Research			

BSU	$55,000
ISU	$55,000
UI	$55,000
LCSC	$20,000
Idaho Conference for Undergraduate Research (ICUR)	$32,000
One-time money	
Total Undergraduate Research	**$217,000**
Administrative Costs	
FY20 Administrative Costs	$2,700
Total Administrative Costs	**$2,700**
Total Budget / Allocation	**$3,635,770**

NOTES

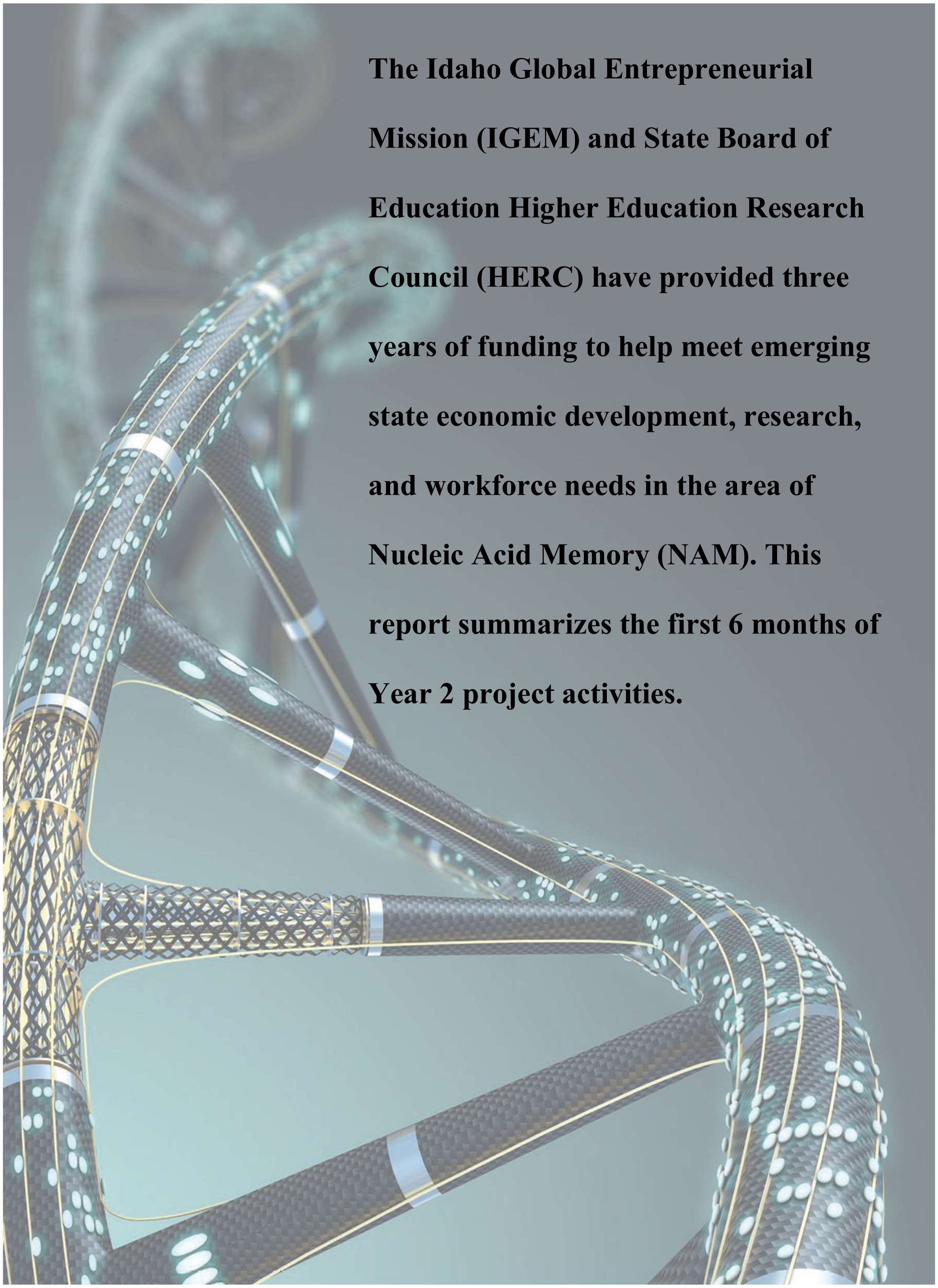
BOISE STATE UNIVERSITY

IGEM # 19-002: Nucleic Acid Memory

July 1, 2019 – January 1, 2020 Progress Report

Will Hughes
Tim Andersen
Eric Hayden
Wan Kuang
Will Clay
George Dickinson
Luca Piantanida
Chad Watson

I. Project Summary



The Idaho Global Entrepreneurial Mission (IGEM) and State Board of Education Higher Education Research Council (HERC) have provided three years of funding to help meet emerging state economic development, research, and workforce needs in the area of Nucleic Acid Memory (NAM). This report summarizes the first 6 months of Year 2 project activities.

II. Project Overview

In 2016, the digital universe produced 16 ZB (1 ZB = 1 trillion GB) of data. In 2025 it will create 163 ZB. These data, once generated, cascade through the information lifecycle — from primary storage media in the form of hard disks and solid-state drives to archival media such as tape. While the semiconductor industry maximizes the density, stability, and energy efficiency of electronic and magnetic memory, both are fast approaching their physical and economic finish lines. As envisioned by the new Semiconductor Synthetic Biology Roadmap, DNA-based massive information storage is a fresh start for memory manufacturing in the United States. According to our study with Micron, Harvard, and the Semiconductor Research Corporation (SRC), DNA has a retention time that ranges from thousands to millions of years, 1 kg of DNA can store the projected digital universe in 2040, and DNA's energy of operation is 100 million times less than current electronic memory. As a result, nucleic acid memory has become a global conversation, a national investment, an industrial opportunity, and a local strength in Idaho.

Our vision is to pioneer a digital data storage paradigm in Idaho by designing, building, and testing accessible, editable, and non-volatile nucleic acid memory (NAM) technologies that are inspired by DNA circuits and made possible by our innovations in DNA nanotechnology. With support from IGEM-HERC, we are creating a Nucleic Acid Memory Institute to meet critical innovation, economic, and workforce development needs in Idaho. To expedite our vision of Idaho becoming a global leader in NAM, five tasks are being addressed over the life of the IGEM-HERC: **Task 1** – Create efficient algorithms for coding information into data strands. Error correction strategies will account for DNA insertions, deletions, and substitutions, as well as screen for biological sequences to ensure that the data has no genetic function. **Task 2** – Create a high-throughput, integrated analytical engine to design and select data strands using quantitative metrics based on an in-house, algorithm. **Task 3** – Create synthetic biological factories for manufacturing DNA scaffolds using rapid design-build-test cycles of genomes. Genome size and structure will be engineered. **Task 4** – Design and fabricate NAM storage platforms using the DNA scaffolds, and validate the functionality of genome scaffolds using atomic force microscopy. **Task 5** – Read arbitrary data files into NAM storage nodes using super-resolution microscopy. Realize sub-nanometer imaging resolution to enable high areal density data storage.

This progress report spans July 1, 2019 to January 1, 2020. Listed below is a technical summary of our accomplishments during this time period.

III. Summary of project accomplishments

The support provided by IGEM-HERC during year 1 of this project provided the infrastructure and team to create the first digital Nucleic Acid Memory (dNAM) proof-of-concept. Building on this foundation, which was described in the July 1, 2018 to June 30, 2019 Annual Report, we conducted a series of experiments to validate dNAM, which provides key insights into the future of a DNA-based information storage roadmap. This work has led to a manuscript to be submitted next reporting period to either Nature Materials or Nature Communications. The content of the manuscript is highlighted below and represents the project tasks during this reporting period. The work is transdisciplinary by nature and highlights collaboration between materials science, computer science, biomolecular sciences, and electrical engineering at Boise State University.

Encoding and recovery of 'Data is in our DNA!\n' using dNAM

We designed an information encoding/decoding algorithm that combines fountain codes with a custom error detection scheme for dNAM. Fountain codes are intended for transmission of data over noisy channels and have great potential to generate a limitless sequence of encoding packets (called "droplets") from a single source message. Droplets can be received in any order and still be decoded to retrieve a message, regardless of the exact distribution of the droplets collected. With our error correction scheme, decoding of individual origami (each origami encodes a single droplet, plus indexing and error-correction information) is robustly achieved even in the presence of high noise by determining the minimum number of operations required to resolve the errors detected by the error detecting code (i.e. minimum edit distance). Combined with the redundancy provided by the fountain code, this leads to recovery of the entire data file with high reliability.

To test our dNAM data storage protocol, we synthesized fifteen unique 6 x 8 grid DNA-origami structures with the encoded random-access message '*Data is in our DNA!\n*'. Each of the memory blocks contained a 4-bit binary index (0000 - 1110), a 16-bit data droplet, 20 bits for parity checks, 4 bits for checksums, and 4 bits acting as orientation markers (Fig. 1A). To rapidly recover the message encoded in the blocks, we used DNA-PAINT to optically image a mixture of the dNAM blocks—below the diffraction limit of light—in a single recording (Fig. 1B, DNA-PAINT). Once DNA-PAINT had been used to identify the positions of all data strands in the 512 x 512 pixel field of view, a custom image processing algorithm was used to rotate and fit the data strands to a 6 x 8 grid and translate the signal detected at each grid location to a 48 bit binary string (Fig. 1B, Processing) for error correction, data recovery, and message reconstruction (Fig. 1B, Error Correction and Decode). We were able to identify all data strands in every origami (Fig. 2) from a single DNA-PAINT recording of 4 μl of a 5 nM mixture of DNA-origami (approximately 4,500 individual DNA-origami). By doing so, all fifteen origami were decoded to successfully retrieve the message '*Data is in our DNA!\n*'.

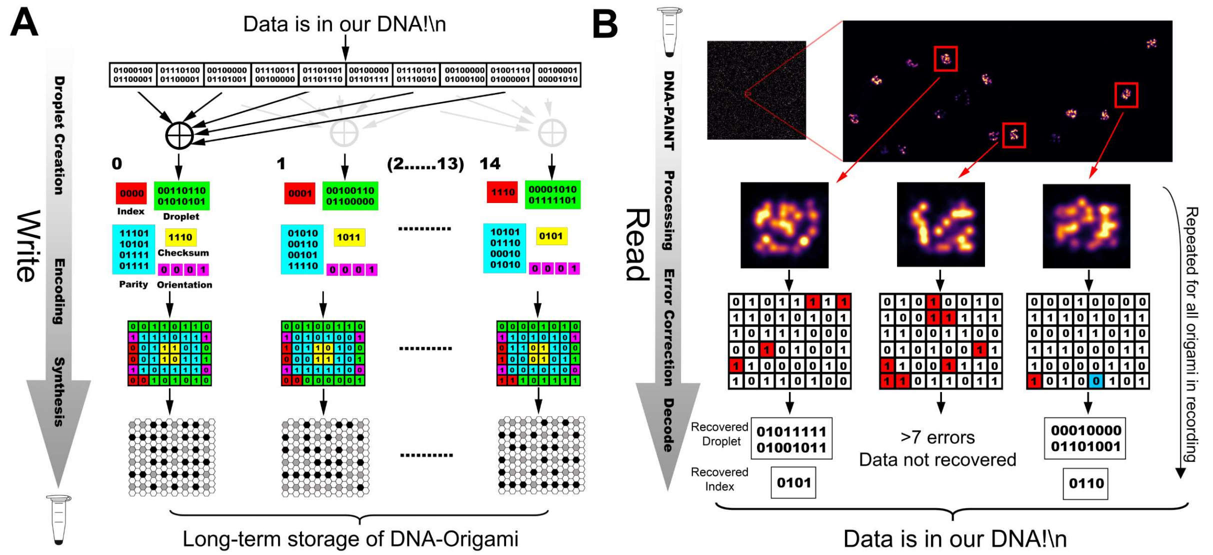


Figure 1. (A) Write: dNAM data packets can be written, stored, and read using DNA-origami and DNA-PAINT imaging. To 'Write' our test message ('Data is in our DNA!\n') fifteen DNA-origami were synthesized based on designs generated by the encoding algorithm in three steps depicted vertically in (**A**). For clarity the writing process is only shown for three of the fifteen structures (0, 1 and 14), however, the same process was carried out for all origami synthesized. First, the test message was partitioned into 16 bit non-overlapping segments and droplets formed by combining the segments via binary XOR (⊕) operations (**A. Droplet Creation**). The data droplets were assigned binary indexes (0000-1110), had parity and checksum bits calculated and were mapped to a 6 x 8 array, along with 4 orientation maker bits. The colors of the index (red), droplet (green), parity (blue), checksum (yellow) and orientation (magenta) bits correspond to their mapped positions in the array (**A. Encoding**). Finally, 2D DNA-origami with 46 addressable data-staples situated at ~10 nm intervals in a 95 x 70 nm hexagonal lattice were synthesized. Data-strands including binding domains for M1 imager probes represented binary '1' data points (black), while data-strands representing '0' (light grey) did not have a binding site extension (**A. Synthesis**). Following synthesis, the origami were gel purified, combined in equal amounts (~0.33 nM final concentration of each origami) and stored at 4°C. **(B) Read:** The four 'Read' steps used to recover the test message from the DNA-origami suspension are shown in (**B**). 4 ul of the DNA-origami mixture (containing all 15 origami) was diluted to 0.05 nM total origami DNA (0.5 TBE, 18 mM $MgCl_2$), deposited onto a glass coverslip using Glow discharge and imaged using DNA-PAINT with Cy3b-labelled imager probes complementary to the binding domains of the data-strands. A rendered image of the full-chip recording (~ 54 x 54 µm) is shown (**top left**) with a zoomed-in view of several individual DNA-origami (**top right**), one of which is a triangular structure used to aid drift correction (**D. DNA-PAINT**). The origami in the rendered image were identified using cluster analysis, individually fit to a 6 x 8 grid and thresholded to obtain binary outputs for each position of the array (**B. Processing**). Once the origami images were converted to 48 bit binary strings the decode algorithm used the parity, checksum and orientation bits to correct errors where possible. In the three representative origami structures, both false negative (red squares) and false positive (blue squares) are observable (**B. Error Correction**). When there were ≤7 total errors in a binary string with at least 13 data droplets and indexes recovered, the decode algorithm corrected errors and successfully retrieved the entire message (**B. Decode**). At the concentration of DNA deposited, all of the data droplets and indexes, and thus the entire message, were correctly decoded from a single 40,000 frame DNA-PAINT recording.

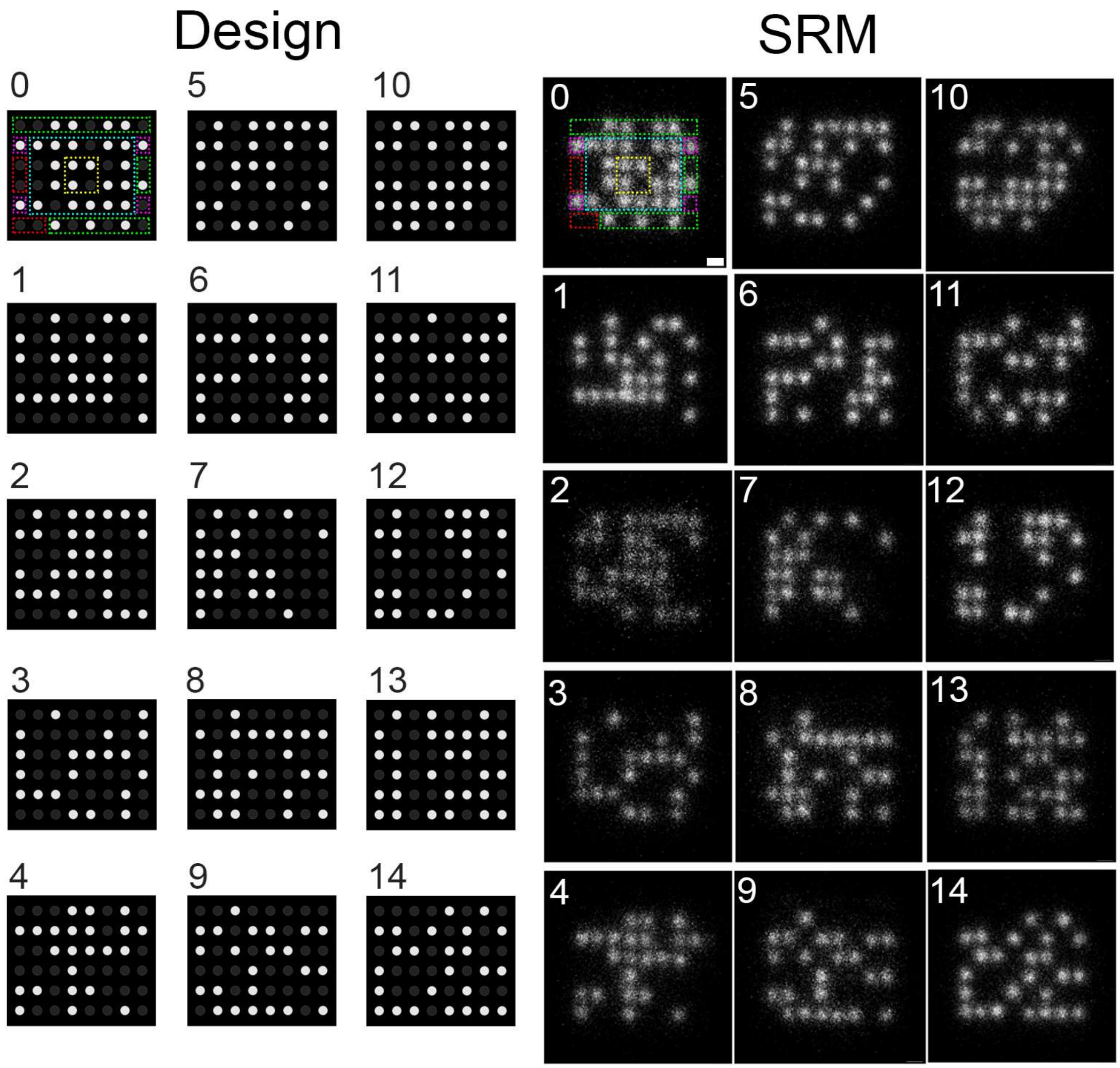


Figure 2. DNA-PAINT imaging of origami designs indicate all sites are recovered in a single recording. DNA-origami from a DNA-PAINT recording were identified and classified by aligning and template matching them with the 15 origami designs (**Design**) in which all potential docking sites are shown, filled circles indicate sites encoded '0' (black) or '1' (grey). Dashed boxes indicate the regions of the matrices used for indexing (red), droplet data (green), error correction (blue), checksums (yellow) and orientation (magenta) — to avoid repetition, only origami design 0 is highlighted. 'Averaged' images of 4560 randomly selected DNA origami, grouped by index, are depicted right (**SRM**). Scale bar, 10 nm.

Input / Output Variability

Comparing the decode algorithm output with each of the 15 input origami designs (each having a total of 223–338 structures within the 5 nM mixture mixture) indicate varying numbers of each origami were successfully recovered. For example, while on average only ~6 copies of origami design 2 were correctly decoded per experiment, ~147 copies of origami design 6 were successfully decoded (Fig. 3A, B). These differences in recovery can partially be explained by the variability in the numbers of errors seen in each structure (Fig. 3C). Specifically, the decode algorithm was only able to error-correct origami with 7 or fewer total errors, and only up to two false positive errors. The mean errors of the best recovered origami designs (1, 5, 6, 12 and 14) are all lower than these thresholds. A plot of the origami decoded against the mean error rate indicates that there is a strong relationship between both the total number of errors and the number of false negative errors and the ability of the algorithm to decode an individual origami's data (Fig. 3D). False positives errors, however, are randomly distributed around a mean of 2, but with a wide

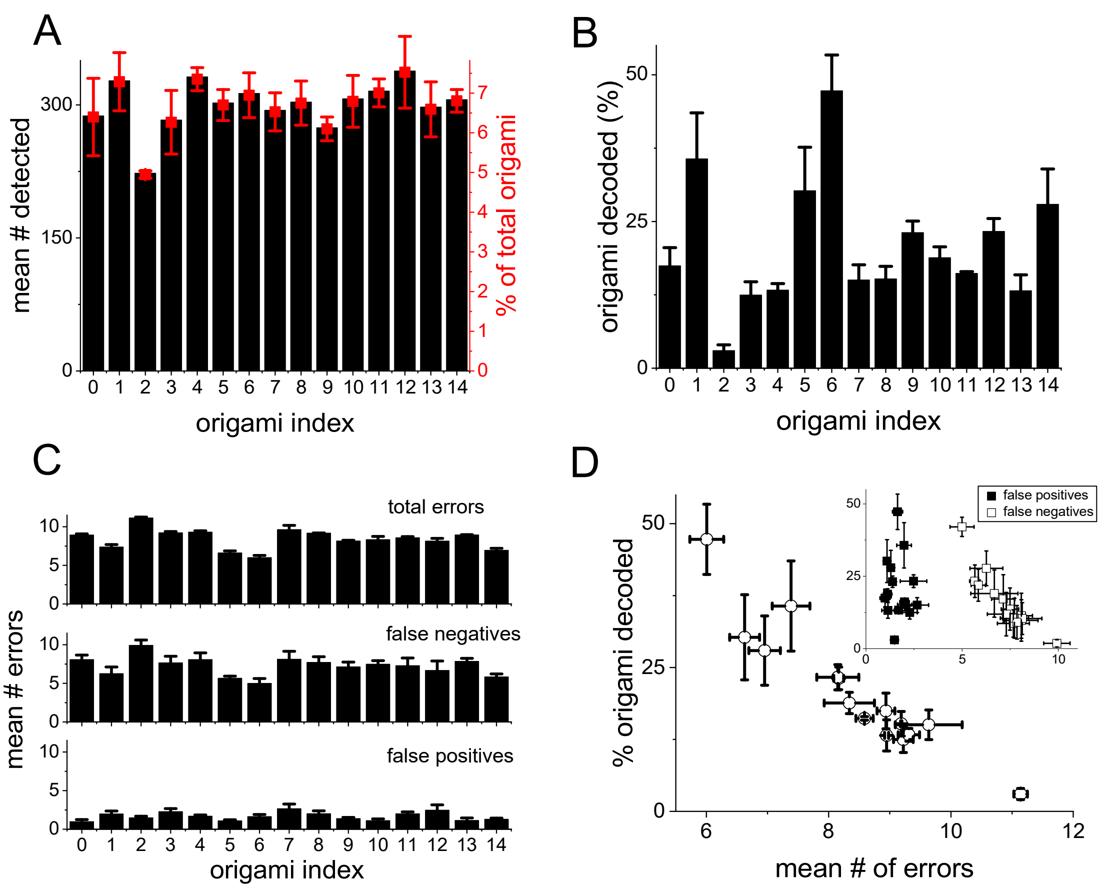


Figure 3. After image processing the origami were assigned an index based on their similarity to the origami designs. The left histogram (**A**) indicates the numbers of individual origami identified from a single full-chip DNA-PAINT recording (512 x 512 pixel sensor) based on similarity to the designs (mean counts shown as black bars, percentage of total origami in red). These origami were also decoded using the decode algorithm. (**B**) Depicts the percent of origami passed to the decode algorithm that had both their indexes and data strings correctly identified. (**C**) The variability in the mean number of false positive (top) and negative (below) error for each structure is shown. In graph (**D**) the percentage of each origami decoded are plotted against the mean number of errors for each structure. Mean values for three experiments are shown throughout, error bars indicate ±SD.

spread of decoded origami (~1–49%) — suggesting that the location of a false positive error within a structure plays an important role in determining whether the origami designs can be successfully decoded.

Source of Errors

By categorizing the errors of origami with 15 or less errors by their positions within an array (outer edge, mid and inner region) and normalizing (dividing the position error by the mean error of all of the sites), it is possible to pool all fifteen different origami designs to see if there are consistent differences between regions. Plots of the mean normalized errors indicate that the outer edges and interior of the array are differentially prone to false negative and false positive errors (Fig. 4). Our results indicate differences in successful strand incorporation between the inner and outer regions that could explain the differences in the numbers of errors observed. However, an alternative explanation could be that data-strands on the outer edge of an array are less likely to be affected by contaminating signals from neighboring sites (which would increase the chances of false positives) and vice-versa for interior sites.

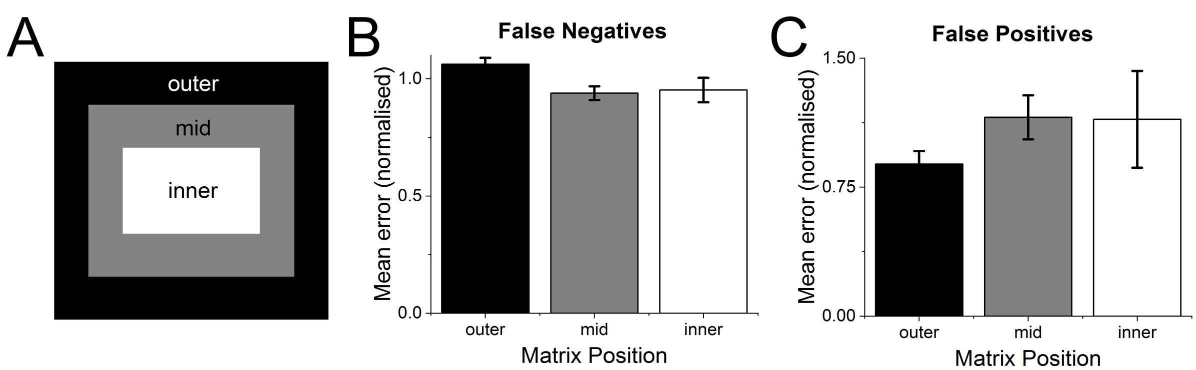


Figure 4. The outer edges and inner regions of origami are differentially error prone. The array positions of origami with 15 or less errors (as identified by pattern matching) were classified as either 'outer', 'mid' or 'inner' depending on their position in the array (**A**). The mean error for each classification was calculated and normalized by dividing by the overall mean error for that zone. Plots of the mean normalized false negative (**B**) and false positive values (**C**) for each zone are shown. Mean values for three experiments are shown, Error bars indicate SD.

To further investigate sources of potential sources of error in our array designs, we performed atomic force microscopy (AFM) imaging on individual DNA-origami deposited on mica. From the averaged SRM images in Fig. 1, it can be seen that every data strand was recorded at least once for all expected positions in all arrays. This suggests that there were no systematic failures in strand incorporation or data-strand binding domains. This is further substantiated by the AFM images, in which origami were typically both well formed (lacking holes and having the expected dimensions) and appeared to have incorporated the majority of their data-strands. Although it was possible to resolve the majority of data strands positions (Fig. 5), a strict analysis on missing data strands using AFM would not be completely reliable since tip-sample interactions could easily promote strand compression and displacement.

We also used AFM to examine DNA-origami deposited onto a glass coverslip immediately following SRM imaging. We were not able to resolve individual binding sites in these images (most likely due to the increased roughness of glass, as compared to mica), however it was possible to count the total number of origami in a field of view for comparison with structures visualized by SRM. The densities of origami estimated from the images were 2.4 and 1.4 origami/μm^2 for AFM and SRM respectively, suggesting that ~60% of the total origami deposited have their binding sites facing away from the coverslip and available for imager strand binding.

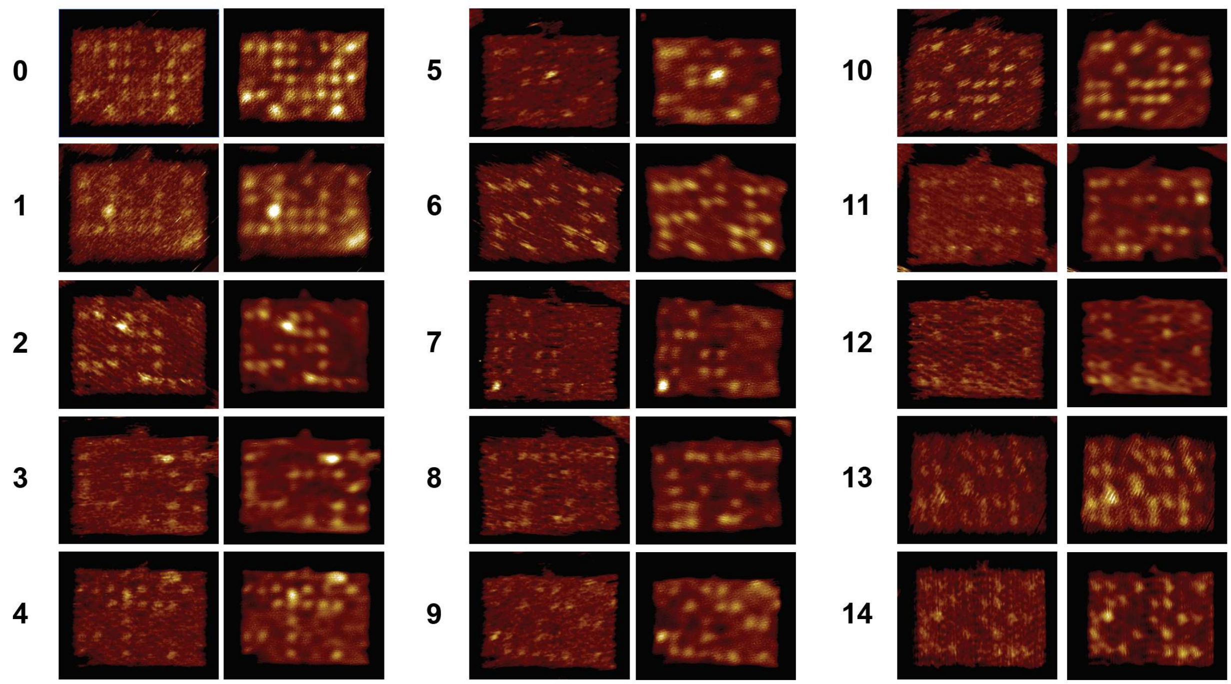


Figure 5. AFM images of DNA origami data nodes. Representative AFM images of all 15 dNAM "Data is in our DNA!/n" data node origami, where most of dockings sites are visible. (An inverse FFT analysis with a band rejected filter has been applied to highlight the dockings positions in right-hand panels). Every image is 90 x 110 nm and the color scale ranges over 250 pm.

Implications

We have created—through a systems-engineering approach—a new technology where digital data is encoded into multiple DNA origami structures and can be retrieved optically below the diffraction limit of light via super-resolution microscopy. By encoding our data using Fountain codes, combined with bi-level error detection/correction, the amount of redundancy required for successful data recovery is minimized (with 100% data retrieval ensured with sufficient node creation). While we have encoded the short message '*Data is in our DNA!/n*' as a proof-of-principal, dNAM platform is scalable and thus has potential for competing with current data storage technologies. For comparisons, our dNAM prototype currently allows for a data storage density 480 Gbit/cm^2, a more than ten-fold improvement relative to state-of-the-art magnetic tape capacity of 31 Gbit/cm^2.

IV. Demonstration of economic development and impact

Demonstration of Economic Development and Impact	Year 1 Reporting Period 07/01/2018–06/30/2019	Current Reporting Period 07/01/2019–01/01/2020
External Funding	$ 1,549,995	0, because we are doing the work
Number of External Grants	3	0, because we are doing the work
Private Sector Engagement	14 companies	2 companies, 1 VC group
University Engagement	11 universities	~20 universities
Federal Agency Engagement	5 agencies	4 (NSF, SRC, NRL, NIST)
Industry Involvement	2 companies	2 companies (Micron, SRC)
Patents	0	0
Copyrights	0	0
Plant Variety Protection Certificates	0	0
Technology Licenses Signed	0	0
News Releases	3 articles	0
Start-up Businesses Started	0	1
Jobs Created outside of BSU	0	6

External Funding

During this reporting period, we did not pursue external funding opportunities. Instead, we devoted ourselves to our current funding from IGEM/HERC, the National Science Foundation, and the Semiconductor Research Corporation. In doing so, we established dNAM as a new memory technology that is both information dense and has the promise of being stable for neo-archival applications. When published, this work will further position our team as a pioneer in DNA memory. Moving forward, the research team is on track to submit one proposal to an external funding agency before the end of the next reporting period.

Engagement

With the backing of the NSF Office of Emerging Frontiers and Multidisciplinary Activities, Hughes hosted the 2019 Germination Meeting at Boise State University on August 15-16, 2019. The meeting focused on new approaches in cultivating risk-taking and impact-driven research culture. As noted in the Year 1 Annual Report, the National Science Foundation (NSF) in collaboration with the Semiconductor Research Corporation (SRC) jointly awarded the research team $1,500,000 to address the scientific challenges facing NAM technologies. The funding mechanism was called *Semiconductor Synthetic Biology for Information Processing and Storage Technologies*. As part of this funding, the SRC holds an annual conference to showcase "*the quality and breadth of the SRC research portfolio, the excellence of SRC students and faculty, and the magnitude of the collaborative research investment made by industry through SRC*." Hughes and two PhD students (now graduated) on the NAM team, Chris Green and Mike Tobiason, attended the conference, which was held in Austin, Texas from September 8–10. "*The conference features student presentations and posters and gives SRC member companies multiple formal and* *informal occasions to network with SRC students. This is a great opportunity for students to meet with SRC member companies, including 7 of the top 10 semiconductor companies in the world. These networking occasions with SRC member companies give student opportunities to open the door to future full-time employment.*"

Hughes was also among a select group of scholars, industry stakeholders, and program managers to participate in a workshop on Nucleic Acid Nanotechnology. The workshop, held in Boston, Massachusetts on Dec. 7, 2019, was co-sponsored by the Materials Research Society and the prestigious Kavli Foundation. The goals of the workshop were to establish "priority research areas for next-generation applications of nucleic acid nanotechnology across diverse domains spanning computation, sensing, fabrication, therapeutics, and other areas." Through this process, Hughes reinforced relationships with Harvard University (George Church, William Shih), MIT (Mark Bathe), NIST (James Liddle), NRL (Igor Medintz), John's Hopkins (Rebecca Schulman), as well as established new relationships with the editors of Nature and Nature Materials. Based on ideas shared, George Church opened his lab to members of the NAM Institute at Boise State.

Business Development

Steven Burden, who successfully completed his PhD in Biomolecular Sciences, graduated December 2019 as a member of the NAM Institute. Burden's dissertation topic was on the development of nucleic acid biosensors with allosteric fluorescence signals. For the NAM team, Burden played a lead role in our Vertically Integrated Project (VIP), where he trained undergraduate students to produce, purify, and ensure the quality control of single-stranded DNA scaffolds. Prior to graduating from Boise State, Burden co-founded a biotechnology startup (FACible BioDiagnostics — https://www.facible.com/). Based in Boise, Idaho, FACible BioDiagnostics is focused on developing rapid, low-cost, diagnostics. Burden began full time employment as the company's CEO on January 1, 2020. In addition, one of the co-founders, Clementine Gibard Bohachek, was a postdoctoral research scientist at Boise State University and was part of the NAM team during the spring of 2019, where she developed VIP training materials and trained VIP and NAM graduate students on practical laboratory approaches to synthetic biology. In all, FACible BioDiagnostics employs 6 people — three full time and three part time. The financial, scientific and professional support that Burden received during his PhD was critical for his ability to secure venture capital needed to start his company. The success of Burden highlights the entrepreneurial environment that is being cultivated by the NAM Institute and team.

V. Numbers of student, staff, and faculty participation

Classification	Number
Tenured or Tenure Track Faculty	4 (*2 full professors, 2 associate professors*)
Research Faculty	1 (*started a tenure-track faculty position*)
Project Manager	1 (*also focused on business development*)
Senior Lab Research Associate	1 (*manages the laboratory & supports team*)
Postdoctoral Fellows	3 (*performing at a research faculty level*)
Graduate Students	5 (*3 of the 5 graduated in December*)
Undergraduate Students	10 (*5 female and 5 male*)

From a professional development perspective, the goal of the NAM Institute is to ensure the success of the people that make up the team, from students and postdoctoral research scientists to the faculty and staff that enable open innovation, ideation, and collaboration. And with any academic environment, matriculation to graduation is expected, supported, and applauded. Thus, we are happy to report that during this reporting period three PhD students on the NAM project successfully defended their PhD dissertation and graduated:

- **Steven Burden**, PhD in Biomolecular Sciences, Dissertation — *The Development of Nucleic Acid Biosensors with Allosteric Fluorescence Signals*
- **Chris Green**, PhD in Materials Science and Engineering, Dissertation — *Nanoscale Optical and Correlative Microscopies for Quantitative Characterization of DNA Nanostructures*.
- **Mike Tobiason**, PhD in Materials Science and Engineering, Dissertation — *Engineering Kinetically Uniform DNA Devices*

In addition, Reza Zadegan has started a tenure track faculty position at North Carolina A&T this past August. His professional development included but was not restricted to: grant writing support by Watson and Hughes; germination of research directions and intellectual risk management by Hughes; helping create his faculty package by Hughes, Andersen, and Hayden; mock interviews by Hughes; national and international networking opportunities by Hughes; technical training by Andersen, Hayden, Kuang, and Hughes; and professional training from Hughes and Watson. We also would like to acknowledge that one of the project principle investigators, Elton Graungnard, has transitioned from the team to focus his efforts on developing atomically-thin semiconducting materials for high performance, energy-efficient electronic devices. While Graungard's absence will be missed, we have hired a new postdoctoral research scientist, Luca Piantanida, who started on August 5, 2019. Piantandia's complementary expertise enables the team to move forward without needing to make course adjustments. Piantanida has a PhD in Nanotechnology from University of Trieste, where his dissertation was on developing DNA origami nanoactuators functionalized with gold nanoparticles for plasmon resonance tuning. Piantanida recently concluded a postdoctoral position at Durham University, UK under the supervision of Prof. Kislon Voïtchovsky, where he developed a novel atomic force microscopy approach for imaging biological interfaces in fluid. His expertise with DNA origami and high-resolution imaging, coupled with the scientific expertise and productivity of postdoctoral research scientists Drs. Will Clay and George Dickinson, position the NAM Institute to accelerate our development rate.

Vertically Integrated Project

The Vertically Integrated Project (VIP) model integrates teaching and learning into one framework in support of work-force development of students that can work at the interface of semiconductor manufacturing and synthetic biology. These students are engaging in research activities aimed toward the production, purification, and quality control of new single-stranded DNA origami scaffolds. The students range from sophomore to seniors and span four different majors: biology, chemistry, health sciences, and psychology. Specifically, the VIP students synthesized and purified several large DNA scaffolds. They used *E. coli* cultures to express single stranded DNA ~8,000 and 10,000 bp in length. Currently, the bacteriophage M13mp18 is used to make the DNA scaffolds, but it limited to 7249 nucleotides. In addition to being longer than M13mp18, each of these scaffolds has a different sequence, potentially enabling orthogonal origami synthesis.

VI. Description of future plans

Team Management – Integration and graduation

- Manage the financial risk of the anticipated higher education budget cuts in Idaho that have the potential to impact the NAM Institute.
- Target the next round of grant opportunities and start working towards their submission. Leverage the grant writing process as an opportunity for professional development of the postdoctoral fellows.
- Help the postdoctoral fellows identify the intellectual space they want to lead in the future; periodically meeting with them to establish their professional development plans.
- Seek collaborations with key internationally recognized research groups; with an eye for cross-training our laboratories.
- Support our project manager to visit federally funded research centers to solicit effective practices in how to mobilize, pitch, and manage a large federally-funded effort.

Task 1 – Create improved algorithms for coding information into data strands.

- Explore the integration of Tasks 1 and 2 together to expand *DevPro* and *SeqEvo* to include machine learning so that our experimental results help inform future sequence design.
- Submit the initial manuscript describing and encoding/decoding algorithm into DNA to **DNA 26**, as well as a review article on encoding information into DNA to **IEEE** or equivalent.

Task 2 – Create a high-throughput, integrated analytical engine to design select data strands using quantitative metrics based on an in-house, algorithm.

- Resubmit the initial manuscript describing *SeqEvo* and *DevPro* to **Nucleic Acid Research**. Initial reviews from the journal reinforced the value of the research, as well as the need to communicate it more clearly because of our attempt/need to bridge multiple disciplines.
- The first version of our evolutionary sequence-generation tool (*SeqEvo*) and our sequence-analysis tool (*DevPro*) have been released to select research groups at Boise State University, the National Institute of Standards and Technology, and the Naval Research Laboratory to solicit their technical feedback in preparation for releasing both tools publicly. Based on their feedback, finish and then make publicly available *DevPro* and *SeqEvo* versions 2.0.
- Scale the adoption and adaption of *SeqEvo* and *DevPro* in support of Tasks 3 and 4.

Task 3 – Create a synthetic biological factory for manufacturing DNA scaffolds using a rapid design, build, and test cycle of genomes.

- With the successful development of software to optimize sequences (Task 2), we will next set out to design and synthesize large scaffolds with sequences optimized for our specific origami designs. Several designs will be synthesized and compared. The super resolution microscopy advancements will aid in this comparison. This will require Tasks 2, 3, and 4 to further integrate.
- Develop quality control metrics for scaffolds. Each scaffold synthesis will need external quality control metrics to ensure batch to batch consistency in order to enable comparison.

Task 4 – Design and fabricate NAM storage nodes using the DNA scaffolds.

- Submit the initial manuscript describing *dNAM* to **Nature Communications** or **Nature Materials**.
- Explore the application of short Locked Nucleic Acid (LNA) and other DNA analogues in dNAM to increase the resolution of the super-resolution microscope during DNA-PAINT, as well as explore if sequence Nucleic Acid Memory (seqNAM) is as viable as dNAM.

Task 5 – Read arbitrary files into NAM storage nodes using super-resolution microscopy.

- Test methods to improve resolution on existing microscope, including reducing drift, improving drift correction, and increasing the signal-to-noise ratio.
- Use knowledge gained from optimizing existing microscope to design and test components for custom built super-resolution microscopy system while working toward a full prototype.
- Use simulation to better understand optimal imaging and sample design parameters to maximize data reading rate.

VII. Summary of Budget Expenditures

The below table summarizes expenditures associated with the project from July 1, 2019 to December 20, 2019. In establishing dNAM as a new memory technology, *Salary* and *Fringe* supported five graduate students, three postdoctoral research scientists, an undergraduate student, an assistant research professor, and a project manager. *Other Expenses* were used to purchase modified and unmodified DNA oligos, supplies to process modified and unmodified DNA oligos into dNAM, super-resolution microscopy supplies, atomic force microscopy supplies, computers, and an upgrade to a liquid handling system (epMotion). The oligos are used to assemble NAM blocks and to perform super-resolution microscopy studies. The atomic force microscopy supplies complement the super-resolution studies by confirming the design and structural stability of the dNAM. The computers were purchased in support of our algorithm development and newest postdoctoral research scientist. The epMotion system enables us automate the mixing of solutions to synthesize DNA origami in both an accurate and efficient manner. The system was malfunctioning and was approaching its end-of-life. The upgrade ensures vendor support throughout the life of this project. The encumbered *Capital* is allocated to the purchase of a server to significantly improve our image processing efficiency and infrastructure. As part of analyzing dNAM, we compile over 60,000 high resolution images (~40 GB) per experiment. Post-processing of each series of experiments, and the 60,000+ images, are computationally intensive. When performed on a desktop computer, processing requires hours to days of processing time per experiment. The server will enhance productivity.

Category	Current Budget	Expenditures	Encumbered	Remaining Budget
Salary	$282,671.00	$118,649.66		$164,021.34
Fringe Benefits	$96,375.00	$29,017.86		$67,357.14
Other Expenses	$93,500.00	$52,004.98	$9,587.64	$31,907.38
Travel	$15,000.00	$480.00	$288.00	$14,232.00
Capital	$150,000.00		$23,689.56	$126,310.44
Student Costs	$28,954.00	$15,881.40		$13,072.60
Total	$666,500.00	$216,033.90	$33,565.20	$416,900.90

VIII. Commercialization Revenue

Commercialization	Revenue
None.	$0

IX. Additional metrics established specific to individual project

Metrics	Number
External Funding	$ 1,549,995
Graduate Degrees Awarded	4 (3 PhD, 1 MS)
Dissertations Published	4 (3 PhD, 1 MS)
Invited Technical Presentations	15 (5 oral, 10 poster)
Software Tools Created	3
Peer-Reviewed Publications	1
Manuscripts in Preparation	4
Number of Graduate Students on the Project	2
Number of VIP Students Enrolled (grad and undergrad)	10
Number of National and International Postdocs Hired	3
Number of Scientists that have become Tenure Track Faculty	1 (North Carolina A&T)
Number of PhD Students that have received Postdoc Fellowships	1 (NRC Fellowship)
Number of PhD Students that started a Company in Idaho	1 (6 employees)

Note: Listed above are specific, objective, measurable, and realistic performance metrics over the lifetime of the project. These metrics, many of which have been distributed throughout this report, are a reflection of project success and inform economic impact.

Idaho State University

College of Science and Engineering

Department of Civil and Environmental Engineering

IGEM20-001

A Disaster Response Complex for Emergency Responders in Idaho

1st Progress Report

July 1, 2019 – December 31, 2019

January 20, 2020

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., Assistant Professor

Co-Principal Investigator

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

Report Type

1st Progress Report: July 1, 2019 – December 31, 2019

2.0 Executive Summary

In the post 9/11 years, the national demand for training of first responders from the military and law enforcement branches has grown rapidly. There is more demand for emergency training of the first responders than the current facilities can support. Recently, researchers at Idaho State University were awarded funding from the State of Idaho under HERC-IGEM grant. The focus of the project is the development of a Disaster Response Complex (DRC) for research, certification, and training of first 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, 3) training. The research pillar includes the development of new training lanes/simulations/Chemical, Biological, Radiological, Nuclear, and high yield Explosives (CBRNE) surrogates and markers, the use of robots/small Unmanned Aerial Vehicle (sUAV), virtual reality, augmented reality, and Geographic Information System (GIS) in the training of first responders. The curriculum pillar includes offering courses in topics such as emergency response and gamma/chem spectroscopy. In the final pillar of training, the facility can be used to host events for clients such as the Department of Defense (DoD) CBRNE Response Enterprise (CRE) customers, 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 training of first responders.

3.0 Summary of Project Accomplishments

This is the first progress report for the project. First year budget for the project is $525,100. The formal project award letter from Idaho State Board of Education (SBOE) was received on August 7, 2019. The Principal Investigator (PI) and the project personnel at Idaho State University (ISU) have had progress on all three pillars of the DRC project which is detailed below.

A. Research Pillar

Efforts in the research pillar have focused on the use of robotics and Chemical, Biological, Radiological, Nuclear, and high yield Explosives (CBRNE) markers/surrogates in a collapsed structure for the training of first responders.

- On the robotics side, ISU researchers have discussed ideas with collaborators from Idaho National Laboratory (INL). INL has good capabilities, facilities and experts in robotics. Through the discussions, an ISU graduate student was identified and assigned to work with the INL group. The student is focusing on the research aspect of the DRC and will be jointly supervised by senior researchers from ISU and INL. The graduate student (PhD level), collaborators from INL, academic advisor and supervisor from ISU have been identified. The student’s paperwork is currently being processed for access to labs and facilities at INL. The student will be working on adding capabilities to an existing INL’s robot (e.g. enhancement for end of arm tooling, attachment of sensors, detectors, and ground penetrating radar) to enhance its performance for disaster response.
- On the CBRNE side, several meetings were held at the CAES between ISU and INL researchers. The meetings were focused on the development of chemical and biological markers. Collaborators from INL are well-established in the radiological and nuclear detection areas. Available opportunities for research in development of markers/surrogates from agencies such as the Defense Threat Reduction Agency (DTRA) were discussed. This effort is continuing.
- Other technologies such as the use of sUAV and GIS have also been considered for applications in disaster response. INL has good capabilities in sUAV. In addition, the project personnel have discussed collaboration with the College of Technology at ISU which has several sUAVs, some with Light Detection and Ranging (LIDAR) capabilities.

- A graduate student attended the 9th Annual Energy Policy Research Conference in Boise, Idaho in September 2019. The student participated in the discussions and presented a poster from the project.
  - D. Garz, J. Cantrell, K. Hogarth, M. Mashal, and B. Savage (2019). A Disaster Response Complex for Training of First Responders in Idaho, 9th Annual Energy Policy Research Conference, Boise, ID, United States.

B. Curriculum and Certification Pillar

- On the curriculum side, the project personnel had several meetings with instructors/researchers from INL. This included tours of facilities and capabilities at ISU. The instructors have shown interest in organizing short courses (e.g. 4-days) with hands-on components with topics such as gamma spectroscopy and chemical spectroscopy. Courses will be developed at different levels (e.g. basic to advance) and targeting clients such as Civil Support Teams (CST), members of the Homeland Response Force (HRF) and local responders. The plan is that ISU will provide all the necessary facilities for these classes, including a website for registration and payment. ISU will also help INL in developing tabletop exercises for the advertisement of the class. The project personnel have reached out to ISU's Continuing Education/Workforce Training in the College of Technology who already have a mechanism for advertising, registration and fee payment.
- Instructors from ISU and INL held discussions on identifying topics and developing modules for short classes.
- Technical Resources Group, Inc., a consulting firm specializing in radiological training, reached out to ISU regarding the Transportation Emergency Preparedness Program (TEPP) Training - Modular Emergency Response Radiological Transportation Training (MERRTT) and other topics.
- The Idaho Office of Emergency Management has shared the Technical Rescue Team Skill Sheets with the project personnel. The researchers at ISU are currently examining these sheets to identify the type of resources needed for certification of first responders in Idaho.

C. Training and Exercise Pillar

- This pillar includes the design and construction of an outdoor collapsed structure. The original footprint of the collapsed structure was 200 ft x 200 ft, the total area of the outdoor training and exercise facility was about 1-acre. The collapsed structure would house several training lanes such as subterranean, car-rescue, and shoring with possibilities for future expansion. ISU held several meetings with potential users from Idaho National Guard, Idaho National Laboratory, Idaho Office of Emergency Response, Snake River Search, and Idaho Falls Fire Department to gather their input/feedback for the outdoor facility and the training lanes. The Pocatello Fire Department is also interested to use the facility for training exercises. Based on the feedback of the potential users, the Idaho National Guard indicated to enlarge the size of the overall facility to about 3-acres to accommodate the HRF training sessions which typically can have between 500-800 responders training at once. The CST units are smaller (e.g. 22 responders) compared to HRF, but they hold more frequent training sessions (e.g. 12 times per year). The Idaho National Guard also indicated a desire for adding another training lane for high-angle rope rescue. It should be noted that the outdoor facility will be utilized toward all three pillars of the DRC. The aforementioned stakeholders shared their needs for a training complex such as the DRC. They also provided ISU with information on the upcoming major training and exercise such as the Cascadia Rising 2022 in Idaho and the Wasatch Quake 2021 exercise in Utah. The contact at the Idaho National Guard, who is the Director of Joint Plans and Training, has shared the information about the ISU's DRC with the National Guard units in the states surrounding Idaho. He stated that the DRC at ISU "is a unique opportunity that, with some thought and input, the National Guard can leverage and fill a gap in available high-quality training sites in the western US without expending DoD funding".

- The project personnel worked with ISU's facilities to find a suitable location on the campus for the development of the outdoor facility. The unoccupied land behind the Idaho Accelerator Center in Pocatello (Figure 1) was deemed suitable for the outdoor facility. Currently, the site has uneven slopes with a pile of garden waste in the center. Soil composition is mostly silty sand with potential for erosion. A full engineering investigation of the site had to be carried out prior to starting earth work.

Figure 1. Location of the outdoor training facility for the DRC project

- The project personnel carried out the following tasks:
    - Surveyed the site (Figure 2).
    - Collected soil samples (Figure 3) from four test pits.
    - Performed lab tests on the soil samples to determine mechanical properties for cut and fill.
    - Developed cut and fill drawings and data (Figure 4).
    - Worked with ISU's Facilities to obtain the required work permits and identify the contractor (Starr Corp) for the earth work.
    - Developed the scope of work for Phase I of the construction that included obtaining DBS/erosion permits, obtaining estimates for construction, selecting the contractor, relocating all existing soil materials on site, moving, spraying, and compacting the existing bark and brush pile to help cover the exposed soil.
    - Held conversations and visited Teton Prestress Concrete in Idaho Falls (Figure 5), Oldcastle Infrastructure in Idaho Falls and Ogden, and Forterra Structural Precast in Salt

Lake City (Figure 6) to obtain rubble and concrete sections for construction of the collapsed structure and the training lanes.

- Visited several suppliers of heavy equipment in Montana and Utah to identify appropriate heavy equipment for purchase.
- Purchased heavy equipment that included a telehandler and backhoe (Figure 7). This equipment will be used to build basic training lanes, maintain the outdoor facility, and add new lanes based on the training scenarios and the client's need.
- Despite the frozen ground, ground was broken on Monday, Dec 30, 2019 (Figures 8-9).

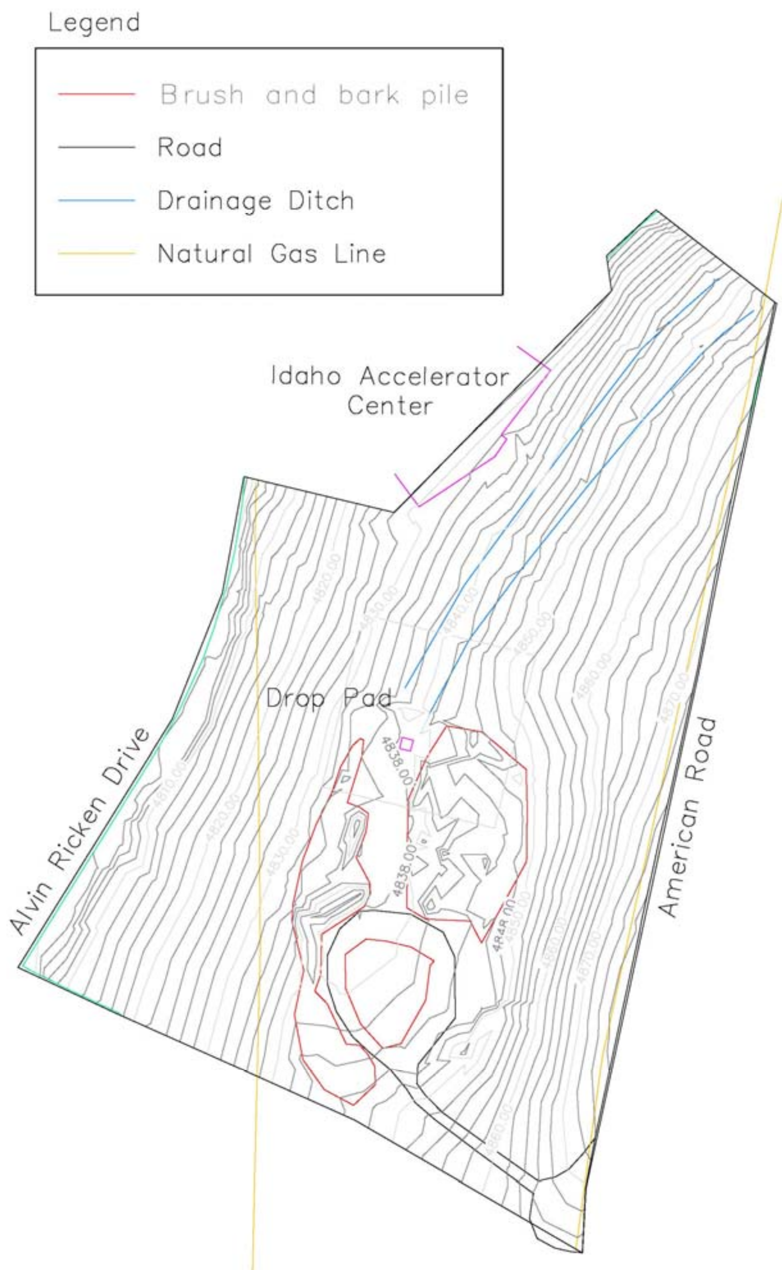


Figure 2. Surveying map of the outdoor training facility, surveyed in October 2019

Figure 3. Test pits for soil sampling

Figure 4. Cut and Fill plan of the outdoor training facility

Figure 5. Precast concrete waste pile at Teton Prestress Concrete in Idaho Falls

Figure 6. Precast concrete waste pile at Forterra Structural Precast Concrete in Salt Lake City

Figure 7. Heavy equipment for the maintenance of the outdoor training facility

Figure 8. Panoramic view of the outdoor training facility location before the start of ground preparation

Figure 9. Start of the earth work on December 30, 2019

- In addition to the outdoor training facility, the efforts are underway to identify an appropriate indoor space for year-round training. Several options were considered for the indoor space, including the Armory Building (Figure 10), research space in the Eames Complex or renting a warehouse type structure in Pocatello. Based on the feedback from INL, Idaho National Guard, and other clients, the Armory Building will be an ideal place for smaller-scale training and offering special focused courses. The building has a high-bay area as well as classrooms and vaults. The Armory Building is owned by ISU and currently houses ISU's College of Technology Diesel Technology program. There are plans to vacate the building in June 2020, with the Diesel Technology program moving to the Eames Complex. The project personnel have been working with ISU's Facilities to use the Armory Building for the DRC project. The building is suitable for the expected activities without any major improvements.

(a) Front View

(b) Back side parking lot

(c) Inside high-bay area

Figure 10. Armory Building at ISU

- Besides the outdoor and indoor facilities, there are several other structures owned by ISU which could be used for special and advanced training by INL. These structures have been identified and may offer the state-of-the-art training in a realistic environment as part of the DRC project. INL's clients have several scheduled exercises in the summer of 2020 where ISU facilities would enhance the training experience. It is expected that each exercise may include 10-20 students. The exact number of participants in these exercises will be confirmed in the spring of 2020.

4.0 Plans for the Upcoming Reporting Period

Plans for each pillar of the DRC project are discussed below.

A. Research Pillar

- The PI will have a presentation on the DRC project at the Winter Collaboration Meeting, January 23-24, 2020 in the CAES Building in Idaho Falls. The meeting is organized by CAES, with more than 140 researchers from the INL and large research universities registered for this event.
- Graduate students working on the DRC project will have a poster titled “A Disaster Response Complex for Research, Curriculum, and Training of First Responders” at the Winter Collaboration Meeting, January 23-24, 2020.
- Submitting an abstract from the DRC project for oral presentation at the 2020 American Society of Civil Engineers (ASCE) Southern Idaho Section Civil Engineering Conference, March 24-25, 2020, Boise, Idaho.
- Submitting an abstract from the DRC project for poster presentation at the 62nd Annual Meeting and Symposium of the Idaho Academy of Science and Engineering, April 11, 2020, Coeur d’Alene, Idaho.

B. Curriculum and Certification Pillar

- Development of materials, identifying the instructors, and procuring the resources (e.g. advertisement, payment system etc.) for 1-2 short classes.
- Obtaining input from stakeholders on Federal Emergency Management Agency (FEMA) Certification requirements and processes.

C. Training and Exercise Pillar

- Starting Phase II of construction for the outdoor training facility. Phase II includes construction of gravel base pad at the location of prepared sub-grade. Eight inches of pit-run gravel topped with four inches of ¾ inch road mix to be applied and compacted, creating a year-round accessible area for training and exercises.
- Purchasing of 200-300 tons of precast concrete pieces as well as other sections (e.g. culverts, pipes, etc.) for construction of the collapsed structure.
- Upon completion of construction (expected to be in June 2020), holding a ribbon-cutting ceremony for the outdoor training facility, inviting potential clients and stakeholders to tour the facility and learn about its capabilities.
- Assisting with the Idaho Association of Boards of Health Annual Conference, June 10-11, 2020. The conference is sponsored by Southeastern Idaho Public Health and will be held at ISU. The event is expected to include 75-100 professionals and will include tour of the outdoor training facility and the training lanes.
- Processing paperwork and contacts with INL and other collaborators for using the DRC facility.
- Procuring the facilities and resources needed for INL’s clients to be trained at ISU in summer 2020.

5.0 Summary of Budget Expenditures

The project expenditure until December 31, 2019 is presented in Table 1. Major charges for ground preparation and materials and supplies will appear in early 2020. Given the increased size of the outdoor training facility and some salary saving due to delay in the arrival of the award letter, a re-budget request is currently being prepared for the DRC project to move funds toward construction and supplies. The PI expects that all the allocated budget for the 1st year ($525,100) will be utilized toward this project by June 30, 2020.

Table 1. Summary of Budget Expenditures

Salaries (faculty, graduate students, research engineer)	$24,954.20
Fringes (faculty, graduate students, research engineer)	$4,870.62
Travel	$1,496.60
Equipment (>$5k)	$92,000.00
Supplies	$4,771.15
Tuition Remission (graduate student)	$4,962.98
Total Expenditure posted through Dec 31, 2019	**$ 133,055.55**

6.0 Partnerships and Impact

- The project personnel have had discussions with the interested individuals and entities listed in Table 2 on this project. The entities listed below are interested to use the outdoor, indoor, and other facilities at ISU for their trainings. Especially, the need for the outdoor training facility has been highlighted as a priority. The project personnel have been working continuously despite the frozen ground and weather conditions to complete the outdoor training facility as soon as possible so the trainings for the clients can be scheduled.

Table 2. Collaborators and Entities

Entity Name	**Number of Collaborators**
Idaho National Laboratory	19
Idaho Office of Emergency Management	2
Idaho National Guard	2
Idaho Falls Fire Department	2
Pocatello Fire Department	1
Technical Resources Group, Inc.	1

Snake River Search, Inc.	1
ISU College of Technology	4
ISU Department of Public Safety	1
ISU Kasiska Division of Health Sciences	1
ISU College of Science and Engineering and Office of Research (excluding the project personnel)	9
Total	**43**

- Although not relevant to the DRC project, the PI (Dr. Mashal) had a provisional patent on energy dissipaters to protect the integrity of precast concrete structures during an earthquake. It is worth to mention that the outdoor collapsed structure for the DRC project will imitate the aftermath of an earthquake.
- As presented in Table 2, ISU is in touch with several industry partners (public and private) who are interested to collaborate on the DRC project.
- 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 as well as co-supervising the students.
- There are plans for developing proposals under the research pillar of the DRC for external funding once the outdoor and indoor facilities are ready to be used.
- ISU is working with some collaborators on this project to attract external funding toward the indoor training facility.

7.0 Faculty and Student Participation

Through Dec 31, 2019, the numbers of faculty, students, and other researchers participating on the DRC project at ISU are listed in Table 3. Appendix 1 provide sample student activities for some of the students working on the project.

Table 3. Participating Researchers

Position	**Numbers**
Faculty	7 (including the PIs)
Graduate Students	2
Undergraduate Students	5
Researchers	3
Total	**10**

8.0 Future Plans

The intent of the DRC is to be a self-sustaining entity by the end of the three years of funding. Future improvements and renovations, adding new training lanes, maintenance of the facility and equipment, and salaries/fringes are intended to be funded through training, research, and certification revenue generated by both the indoor and outdoor facilities. Additionally, future grants and collaborators will be pursued to further develop the facilities for project continuation and expansion.

9.0 Expenditure Report

A detailed breakdown of the expenditure posted through December 31, 2019 is attached in Appendix 1.

10.0 Commercialization Revenue

As noted in the above, the DRC aims to become self-sustaining through revenues collected from training, curriculum, and certification. Additionally, research funding is planned to be pursued in order to benefit the students, faculty, and other researchers.

Appendix 1: Sample Student Activities

Week No.	Dates	Graduate Student # 1	Undergraduate Student #1
Week 1	8/18/2019	Project Intro Meeting with Mashal (19th)	Summarize and Review Literature Review
		Research DRC	
Week 2	8/25/2019	Research DRC	DRC Team Meeting (30th)
		Completed Research Summary	
		DRC Team Meeting (30th)	
Week 3	9/1/2019	Start Preparing TOPO Survey	Continue Development of Concept Design
		Meet Darren to Discuss Survey (4th)	
Week 4	9/8/2019	First TOPO Survey of Project Location (11th)	Construction cost estimations
		Second TOPO Survey of Project Location (13th)	DRC Team Meeting (13th)
		Draw Site TOPO Map	
		DRC Team Meeting (13th)	
Week 5	9/15/2019	Study Civil 3D	Develop Poster presentation for CAES Conference
		Begin Work on Site Plan	Redefine physical model
Week 6	9/22/2019	Work on Site Plan MkII (24th)	Improve and add to physical model
Week 7	9/29/2019	Attend CAES Energy Conference (29th-1st)	Finish Physical model improvments and additions
		Create Power Point for Meeting with INL	
Week 8	10/6/2019	DRC Meeting with INL & Others (7th)	DRC Meeting with INL & Others (7th)
		Work on Site Plan	
Week 9	10/13/2019	Work on Site Plan	
		Submit Plan Set MkVI to Jared (19th)	
Week 10	10/20/2019	DRC Meeting with Idaho National Guard (22nd)	DRC Meeting with Idaho National Guard (22nd)
		DRC Team Meeting Site Pad Design (23rd)	
		TOPO Survey Piles on Project Site (24th)	
		Update TOPO Map	
Week 11	10/27/2019	Work on Site Plan	CAES Tour and Presentation
		Test Pit Excavation (30th)	
		CAES Presentation (1st)	
Week 12	11/3/2019	Work on Site Plan	
		Submit Plan Set 2019.11.8 to Jared	
Week 13	11/10/2019	Lab Testing of Test Pit Samples	
		Scan & Upload Brochure	
Week 14	11/17/2019	Prepare Points for Construction Staking (20th)	Begin container drawings for fabrication
		Lab Testing of Test Pit Samples	
		Construction Staking Survey (22nd)	
Week 15	12/1/2019	Lab Testing of Test Pit Samples	
Week 16	12/8/2019		

Appendix 1:

Week No.	Dates	**Undergraduate Student #2**
Week 1	8/18/2019	
Week 2	8/25/2019	DRC Team Meeting (30th) Literature review on DRC plan Natural hazards in the USA to add with DRC plan Research on the key professional conferences to present DRC and journal papers
Week 3	9/1/2019	Prepare TOPO survey & map of the outdoor collapsed structure site Continue research on possible conferences to attend
Week 4	9/8/2019	DRC Team Meeting (13th)
Week 5	9/15/2019	Literature review on the bleachers/stadium seating's Working on site plan
Week 6	9/22/2019	
Week 7	9/29/2019	Reviewed skill sheets that are used by Idaho Technical Rescue Team provided by IOEM
Week 8	10/6/2019	DRC Meeting with INL & Others (7th)
Week 9	10/13/2019	Review and go over possible training associated with Urban Search and Rescue Task Forces Research on overview of the facilities that were discussed in the meeting Went through the drawing of the Structural Collapsed Venue site of Idaho Army National Guard Camp
Week 10	10/20/2019	DRC Meeting with Idaho National Guard (22nd)
Week 11	10/27/2019	CAES Tour Working on site plan Test Pit Excavation
Week 12	11/3/2019	
Week 13	11/10/2019	Lab Testing of Test Pit Samples
Week 14	11/17/2019	
Week 15	12/1/2019	
Week 16	12/8/2019	

Appendix 1:

Week No.	Dates	**Undergraduate Student #3**
Week 1	8/18/2019	
Week 2	8/25/2019	DRC Team Meeting (30th)
		Research DRC background information and other emergency training facilities in the U.S.
Week 3	9/1/2019	Meeting with Darren Leavitt and Dan Garz to plan for topographical survey
Week 4	9/8/2019	DRC Team Meeting (13th)
		Field data collection of points for topographical map
		Create topographical map of DRC building site using Civil 3D
Week 5	9/15/2019	
Week 6	9/22/2019	
Week 7	9/29/2019	
Week 8	10/6/2019	DRC Meeting with INL & Others (7th)
		Research possible training courses and seating options for training observation
Week 9	10/13/2019	
Week 10	10/20/2019	DRC Meeting with Idaho National Guard (22nd)
Week 11	10/27/2019	CAES Tour
		Geotechnical investigation by excavating test pits at DRC building site and collecting soil samples
Week 12	11/3/2019	
Week 13	11/10/2019	Performed Laboratory testing of soil samples to determine mechanical properties for proposed cut and fill
Week 14	11/17/2019	
Week 15	12/1/2019	
Week 16	12/8/2019	

Appendix 2: Budget Expenditure Report

NAME: **A Disaster Response Complex for Training of Emergency Responders in Idaho**
PRINCIPAL INVESTIGATOR: **Mustafa Mashal**
CLOSING DATE: **12/31/2019**
FUNDING SOURCE: **Idaho State Board of Education**

Budget	**98,113.00**	**80,000.00**	**35,399.00**	**50,288.00**	**11,300.00**	**149,100.00**	**80,000.00**	**20,900.00**	**525,100.00**	
	Salaries	Irregular Salaries	Summer Salary	Fringe	Travel	Equipment	Supplies	Tuition	Current Total	CUMULATIVE EXPENDITURES
Jul-19									0.00	0.00
Aug-19									0.00	0.00
Sep-19					56.00				56.00	56.00
Oct-19		868.00		4.07	545.85		950.49	4,962.98	7,331.39	7,387.39
Nov-19	2,692.31	5,909.00		579.97	894.75	51,000.00	253.34		61,329.37	68,716.76
Dec-19	5,384.62	10,100.27		4,286.58		41,000.00	3,567.32		64,338.79	133,055.55
Jan-20									0.00	133,055.55
Feb-20									0.00	133,055.55
Mar-20									0.00	133,055.55
Apr-20									0.00	133,055.55
May-20									0.00	133,055.55
Jun-20									0.00	133,055.55
									0.00	133,055.55
									0.00	133,055.55
									0.00	133,055.55
									0.00	133,055.55
TOTAL	**8,076.93**	**16,877.27**	**0.00**	**4,870.62**	**1,496.60**	**92,000.00**	**4,771.15**	**4,962.98**	**133,055.55**	**133,055.55**
(OVER)/UNDER BUDGET	90,036.07	63,122.73	35,399.00	45,417.38	9,803.40	57,100.00	75,228.85	15,937.02	392,044.45	392,044.45

Appendix 2: Budget Expenditure Report

Data_Description				Accounted Budget		Year-to-Date			
Fiscal_Month						Sep	Oct	Nov	Dec
				Amount	Restricted_Amount	Amount	Amount	Amount	Amount
Index Only	Account			Value	Value	Value	Value	Value	Value
AHRC48_APPR IGEM Response Complex for Eme	Labor			263,800.00	263,800.00	$ -	$ (872.07)	$ (9,181.28)	$ (19,771.47)
		610_Salaries		263,800.00	263,800.00	$ -	$ -	$ (2,692.31)	$ (5,384.62)
			611_Salaries and Wages	0.00	0.00	$ -	$ -	$ (2,692.31)	$ (5,384.62)
		620_Irregular Help		0.00	0.00	$ -	$ (868.00)	$ (5,909.00)	$ (10,100.27)
			621_Irregular Help	0.00	0.00	$ -	$ (868.00)	$ (5,909.00)	$ (10,100.27)
		630_Fringe Benefits		0.00	0.00	$ -	$ (4.07)	$ (579.97)	$ (4,286.58)
			631_Fringe Benefits	0.00	0.00	$ -	$ (4.07)	$ (579.97)	$ (4,286.58)
	Direct Expenditures			261,300.00	261,300.00	$ (56.00)	$ (6,459.32)	$ (52,148.09)	$ (44,567.32)
		700_Travel		0.00	0.00	$ (56.00)	$ (545.85)	$ (894.75)	$ -
			701_Employee Travel Costs	0.00	0.00	$ (56.00)	$ (545.85)	$ (894.75)	$ -
		720_Services		112,200.00	112,200.00	$ -	$ (738.90)	$ (135.00)	$ (332.69)
			721_Employee Development Services	0.00	0.00	$ -	$ -	$ -	$ (272.69)
			722_General Services	0.00	0.00	$ -	$ (75.00)	$ -	$ -
			724_Professional Services	0.00	0.00	$ -	$ (663.90)	$ -	$ -
			729_Repair and Maintenance Services	0.00	0.00	$ -	$ -	$ -	$ (60.00)
			741_Rentals and Operating Leases	0.00	0.00	$ -	$ -	$ (135.00)	$ -
		730_Supplies		0.00	0.00	$ -	$ (211.59)	$ (118.34)	$ (3,234.63)
			734_Repair and Maintenance Supplies	0.00	0.00	$ -	$ -	$ -	$ (3,035.63)
			736_Institutional/Specific Use	0.00	0.00	$ -	$ (211.59)	$ (118.34)	$ (199.00)
		800_Capital Outlay		149,100.00	149,100.00	$ -	$ -	$ (51,000.00)	$ (41,000.00)
			850C_> $5K Specific Use Equipment	0.00	0.00	$ -	$ -	$ (51,000.00)	$ (41,000.00)
		870_Educational and Training Assistance		0.00	0.00	$ -	$ (4,962.98)	$ -	$ -
			871_Educational and Training Assistance	0.00	0.00	$ -	$ (4,962.98)	$ -	$ -
	Subtotal			525,100.00	525,100.00	$ (56.00)	$ (7,331.39)	$ (61,329.37)	$ (64,338.79)
Total by COLUMNS				525,100.00	525,100.00	(56.00)	(7,331.39)	(61,329.37)	(64,338.79)

Total **($133,055.55)**

INTEGRATED DESIGN LAB
University of Idaho

HERC-IGEM
Cellulosic 3D Printing of Modular Building Assemblies

FIRST MID-YEAR REPORT
FISCAL PERIOD – SEPTEMBER 1, 2019 - JUNE 30, 2020

SUMMARY OF PROGRESS
January 1, 2020

Prepared for:
HERC-IGEM
Ms. Cathleen McHugh

Authors and Contributors:
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CONTENTS

ACRONYMS AND ABBREVIATIONS

3D printing	Three-dimensional printing
AM	Additive manufacturing
IDL	Integrated Design Lab
UI	University of Idaho
BSU	Boise State University
CM	Construction management

1. INTRODUCTION

The project objective is to identify the methodology, process, and materials necessary to three-dimensional cold print (3D print) building assemblies utilizing, to some maximum extent, wood products. Moving a significant portion of construction into a factory setting where labor and work is organized and executed more efficiently will have the following benefits: 1) increase the quality and energy efficiency of buildings; 2) lower overall construction costs; 3) provide appropriate compensation for a more skilled labor force and, 4) assist in mitigating the current construction skilled labor shortage challenge in Idaho.[i]

The outcome of this research is the development of a reliable and cost-effective process for printing panels (i.e., wall, floor, and roof assemblies) on a horizontal plane using a 3D printing process to produce a structural insulated panel. The proposal end goal is to build panels that are 10 feet wide by 16 to 20 feet in length that can be loaded onto a flatbed truck required to transfer it to the construction site for assembly.

Tasks for Year 1:

1) Research and identify the printing mix of wood/natural fibers, binders and adhesives;
2) Develop the technical description design for a 3D fibrous wood wall printing process, including prototype printer design specifications;
3) Develop the business case for private industry investment.

2. SUMMARY OF PROJECT ACCOMPLISHMENTS FOR THE REPORTING PERIOD JUST COMPLETED

Research and identify the printing mix of wood/natural fibers, binders and adhesives.

Prepared by: Armando McDonald, Ph.D

Year 1, mid-year reporting Dr. McDonald staffing: 1 M.S. student in Chemical Engineering. 1 woman. Salary expenditures and student tuition in the McDonald lab have focused on supporting the research efforts of one M.S. student. Capital and operational expenses are in line with ongoing and projected research activities on wood-resin curing research. Appropriated funds will be expended by the end of year 1.

Initial work was looking as fast setting adhesives, a phenol-resorcinol-formaldehyde (PRF) resin (20%), to mix with screened (10 and 40 mesh) sawmill residues (80%). We blended the resin/wood mix and cold pressed into discs at temperature of 50°C at varying times. This provided some test specimens for initial evaluation (Figure 1).

Figure 1: a) < 10 mesh, b) < 40 mesh PRF resin reinforced Douglas-Fir Wood Chips

We purchased a DHR2 rheometer from TA instruments (Figure 2) and was installed early November 2019. The rheometer will be used to determine the cure characteristics of the resins/adhesives and resin/wood blends. The original PRF resin was analyzed for its setting behavior. We have contacted the supplier to provide a faster curing resin and, we are currently evaluating its properties. We are making good progress.

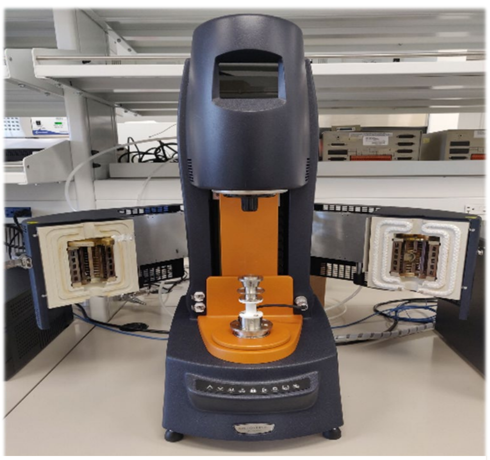


Figure 2. DHR2 Rheometer

Develop the technical description design for a 3D fibrous wood wall printing process, including prototype printer design specifications.

Prepared by: Michael R. Maughan, Ph.D, PE

The University of Idaho (UI) Mechanical Engineering (ME) team has the responsibility of developing a 3D printing process and printer for depositing a wood waste composite mixture developed by other researchers in the UI College of Natural Resources (CNR). The goal is to make bespoke composite building panels. UI ME is also responsible for thermal modeling and optimization of the 3D printed composite building panels. The UI ME team has worked closely with CNR while they have begun developing the composite mixture. In the first period of the project UI ME has accomplished the following tasks: 1) purchasing and setup of key equipment, 2) hiring and training key personnel, 3) conducting a literature search, 4) identifying a suitable approach for depositing the composite mixture, 5) conducting initial experiments of depositing the composite mixture.

Purchasing and setup of key equipment - A multi-core processor computer was purchased for conducting computational fluid dynamics simulations (CFD). The system was ordered in September 2019 when the grant was issued, and became functional for use in early December 2019. The system is available for remote login for any project team members. A copy of ANSYS Multiphysics CFD software has been installed and tested.

Hiring and training key personnel - Upon initiation of the project, a UI ME graduate student was selected. Throughout the fall semester. The student has been undergoing training on existing 3D printing equipment to become familiar with their structure and control. The graduate student has also completed three courses toward a master of science degree. Courses selected provide knowledge benefitting the project and satisfying requirements for M.S. degree.

Literature search and preliminary approach - Collectively 18 relevant references have been identified and reviewed. Specifically, four highly relevant papers regarding printing of biomaterials were reviewed in detail, confirming the novelty of our material system and final product. Based on the mechanical properties of preliminary composite material samples, we selected a screw auger approach as a preliminary test for extruding and depositing the composite mixture. Initial tests with a manual extruder showed some promise leading to testing with a powered extruder. See Fig. 1a and 1b.

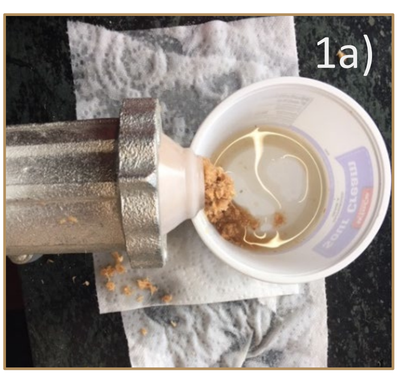


Figure 1 – a) Manual screw-extrusion of wood fibers and water mixture. b) Power extruder used to conduct initial experiments.

Preliminary experiments – Initial experiments indicate a high level of torque required to extrude wood and water. There seems to be a relationship to the level of moisture in the wood and the ability to extrude. Higher torque supplied by the electric powered extruder enabled successful extrusion of the mixture. Further experiments will elucidate performance using resin instead of water. Other deposition techniques are being explored in parallel.

Develop the business case for private industry investment.

Prepared by: Ken Baker, M. Arch and Lyndsay Watkins, Research Assistant

During year one of the grant, a business case is being prepared to show the value of the printing process in producing modular construction panels out of wood. This focused document will provide a research-based explanation of the benefits of the product for purposes of solicitating private investment into development of a production facility that will bring the product to market.

The business case is progressing on time and budget.

To date, we have begun to research the following areas as a prelude to developing a viable business case:

1. reviewed the market potential of our product;
2. reviewed the market potential for modular building;
3. assessed the growth in the construction market (most specifically to Idaho);
4. assessed the job market potential in Idaho construction;
5. researched wood availability for 3D printing;
6. developed a table to compare embodied energy in multiple types of residential and low-rise commercial construction; and,
7. researched the carbon impact of construction materials that are competitive with our 3D product.

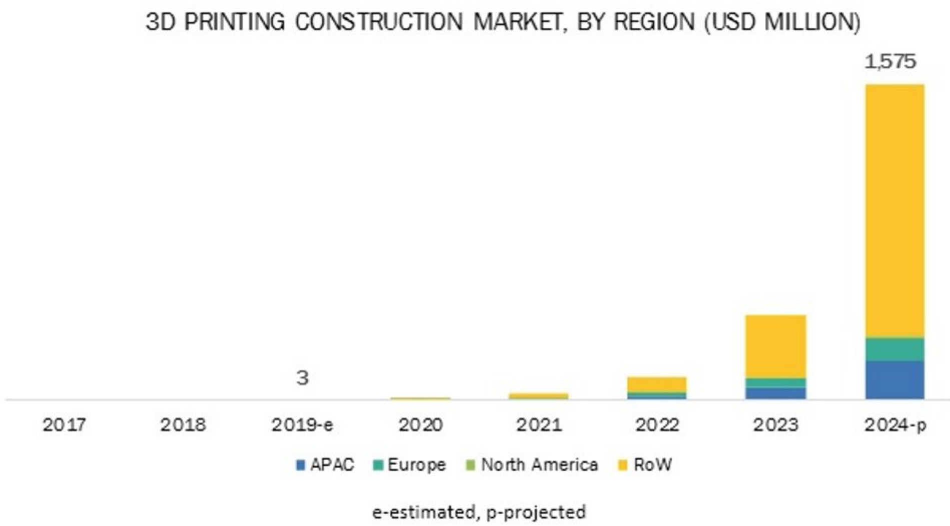
Market Potential for 3D Printing

- The 3D Printing Construction Market Size is Estimated to be USD 3 Million in 2019 and is projected to reach USD 1,575 Million by 2024, at a CAGR of 245.9% Between 2019 and 2024.
    1. https://www.prnewswire.com/news-releases/1-5-billion-3d-printing-construction-market-2024-by-material-type-concrete-metal-composite-construction-method-extrusion-powder-bonding-end-use-sector-building-infrastructure-300912755.htm

Drivers

- Potential for Mass Customization and Enhanced Architectural Flexibility
- Reduction in Health & Safety Risks and Rate of Accidents
- Inherently Green Technology
- Rise in Demand for New Construction Projects Across Regions

- Rising Population
- Increase in Middle-Class Population, 2009-2030
- Rapid Urbanization



1. https://www.prnewswire.com/news-releases/1-5-billion-3d-printing-construction-market-2024-by-material-type-concrete-metal-composite-construction-method-extrusion-powder-bonding-end-use-sector-building-infrastructure-300912755.html

Market Potential for Modular Buildings-

- Sustained industry growth with modular wood waste panels
- Reduces productivity losses
- Idaho has the potential to become a central manufacturing area for modular 3D printed homes

Growth in Construction Market-

- According to the Associated General Contractors (AGC), construction in the U.S. creates 1.3 trillion worth of structures each year and employees over 7 million workers. Business Wire, A Berkshire Hathaway Company, projects that the construction industry, in value terms, is expected to reach a consolidated annual growth rate of 7.6% by 2022. That growth rate would value the U.S. construction market at 1.77 trillion dollars in 2022.
- Modular is quickly growing in the U. S. as a method for controlling labor expenses, increasing overall construction quality, and reducing construction time
- Increase in design and development companies in the US using modular and factory-built design
- One such company builds to Passive House standards and their newest multi-family dwellings come in at less cost per square foot than non-modular, less-efficient buildings which were previously built

Job Market Potential

Construction Industry- Job Creation

- Introducing new sustainable product into the field
- Streamlines construction process with available customizability of panels per project
- Brings attention to potential of waste use to develop construction materials
- Promotes modular construction and flexibility in the construction industry
- Creating jobs in the 3D construction printing field
- Supporting jobs in the construction industry
- Developing a more sustainable product for the construction industry
- Combining with a polymer or resin to create an extrudable product to develop panels for low rise commercial modular construction
- Customizability
- Structural and Insulated panels
- Elimination of thermal breaks- much more efficient construction option
    - New niche market and skill set- 3D Print
    - Designers- New flexible and Green product
    - Forest protect industry- Wood Waste Collection and Use

Supporting jobs in timber industry by utilizing wood waste

- Creating jobs through collection and sorting of wood waste product
- Potential to increase utilization of mills that are not operating at full capacity in the West

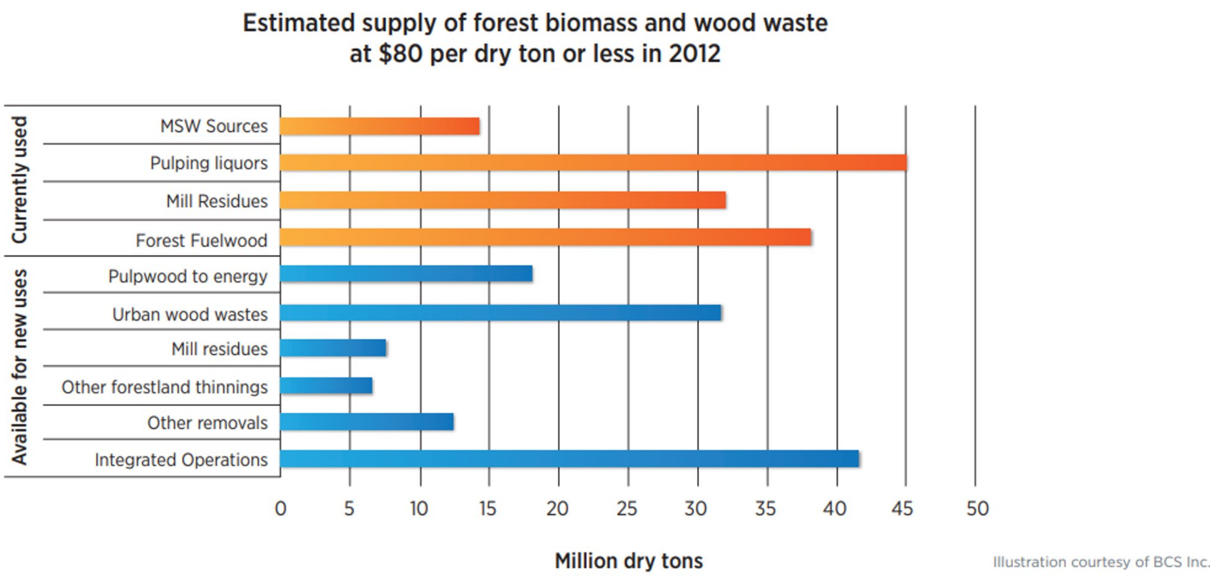
Promotes potential of utilizing sustainable and renewable materials such as wood waste

- Suppliers- New Green Product and Job Specialist
- Manufacturers- Easy Manufacture and Job availability
- Clients- flexibility, simplicity, sustainable and cost effective

Wood Waste Product Availability

- Over the past 30 years, an average of 143.3 million tons of wood-based products were produced annually in the United States (Howard 2012).
    - The manufacture of these products generated about 84 million tons of wood residue (about 40% fine residue, including sawdust, and about 60% coarse residues), with more than 98 percent used by the wood products industries for fuel, pulpwood and feedstock for products such as particleboard (Smith and others 2009, Table 1).

- Its principal sources are municipal solid waste (MSW) and C&D waste.
- In 2010, the EPA estimated that about 15.9 million tons of MSW wood waste were generated, with a recovery rate of only 15 percent (not counting recovery for energy combustion).
- In 2010, 70.6 million tons of urban wood waste were generated (MSW (48%) and C&D waste (52%))
- Residues from primary timber processing mills are not included because essentially all are currently being recovered.
  1. https://www.biocycle.net/2012/08/15/generation-and-recovery-of-solid-wood-waste-in-the-u-s/



*Identified urban wood waste and Integrated operations as most ideal availabilities.

1. https://www1.eere.energy.gov/bioenergy/pdfs/btu_forest_biomass.pdf- numbers for all of US

Embodied Energy Table (under development)

The table below is being developed as a way to compare the total embedded energy costs of six differing construction methods (including our 3D method). This will enable us to ascribe a comparative value, and we believe a value add, to the 3D wood print method.

Comparison Criteria						
	3D	**SIPS (6.5" EPS)**	**Wood Frame (2x6, 24" oc)**	**Steel Frame (16" OC)**	**CMU (8X8X16 block)**	**CLT (12" thick)**
Key Material	Wood	Foam	Wood	Metal	Concrete	Wood
Embodied Energy for Production	Harvest+ Manufacturing	Manufacturing	Harvest+ Manufacturing	Mining + Manufacturing	Mining + Manufacturing	Harvest+ Manufacturing
Embodied Energy of key material (table	6.5 (wood lumber)	256.1 (polystyrene foam i	6.5 (wood lumber)	24 (virgin steel)	25 (concrete)	6.5 (wood lumber)
Transportation						
Where does it come from?	Boise	IBC **Coeur d'Alene, ID**	Arden Lumber, **Colville WA**	SCAFCO **Spokane, WA**	BASALITE Meridian, ID	KATERRA **Spokane, WA**
How is it transported?		By truck	By truck	By truck	By truck	By truck
Labor on Site (10,000 sq ft commercial building)		approx 1688 hours	approx 3,470 hours	approx 3,600 hours	APPROX 1600 HOURS	
Energy Efficiency						
R Value		21	1.25/inch of thickness	0.0124	1.15	1.25/inch of thickness
Energy MJ/kg		101.5	9.25	20.1	0.67	12
Carbon kg CO2/kg		3.9	0.38	1.37	0.073	0.87
Material Density kg.m3		34.244	370-530	7800	2400	500
Price per square foot		approx $3/sq ft	approx $6/sq ft	approx $4/sq ft	approx $12/sq ft	approx $53.25/sq ft
Carbon Emissons (kg C/t)a,b			33	694	291	33

Table of Embodied Energy Values utilized in Embodied Energy Chart

Table 4
Embodied energy values from the IO model and improved IOH model after disaggregation.

Study material	A: IO-based analysis (MJ/kg)	B: IOH analysis without sector disaggregation (MJ/kg)	C: Improved IOH analysis with sector disaggregation (MJ/kg)	Change from IO-based analysis (C-A)/A	Change due to sector disaggregation (C-B)/B
Carpet (3/8″ Thk.), Level Loop	547.2	563.1	**563.1**	3% Underestimation	N/A
Wood Lumber	5.1	6.3	**6.5**	28% Underestimation	4% Underestimation
Hardwood Plywood & Veneer	26.8	35.3	**24.6**	8% Overestimation	30% Overestimation
Softwood Plywood & Veneer	7.0	9.2	**9.2**	31% Underestimation	1% Overestimation
Paints & Coatings	67.4	56.1	**56.1**	17% Overestimation	N/A
Adhesives	130.6	53.5	**53.5**	59% Overestimation	N/A
Plastic Pipes & Fittings	98.2	113.4	**113.4**	15% Underestimation	N/A
Polystyrene Foam Insulation	243.9	256.1	**256.1**	5% Underestimation	N/A
Bricks	4.8	3.9	**4.5**	7% Overestimation	16% Underestimation
Clay Wall & Floor Tiles (1/4″ Thk.)	44.2	35.4	**26.4**	40% Overestimation	25% Overestimation
Vitrified Clay Sewer Pipes	19.5	15.6	**14.3**	27% Overestimation	9% Overestimation
Flat Glass	24.7	24.7	**24.7**	Negligible difference	N/A
Cement	4.4	7.5	**7.5**	69% Underestimation	N/A
Concrete	1.1	1.3	**1.3**	26% Underestimation	N/A
Gypsum, Bldg. Products	21.1	24.1	**17.4**	17% Overestimation	28% Overestimation
Lime	3.9	4.5	**7.4**	90% Underestimation	65% Underestimation
Stone	3.0	3.3	**3.3**	9% Underestimation	N/A
Mineral Wool Insulation	27.5	29.3	**29.3**	7% Underestimation	N/A
Virgin Steel	24.2	24.2	**24.0**	1% Overestimation	1% Overestimation
Primary Aluminum	67.9	186.5	**190.6**	181% Underestimation	2% Underestimation
Copper	43.6	59.9	**59.9**	37% Underestimation	N/A

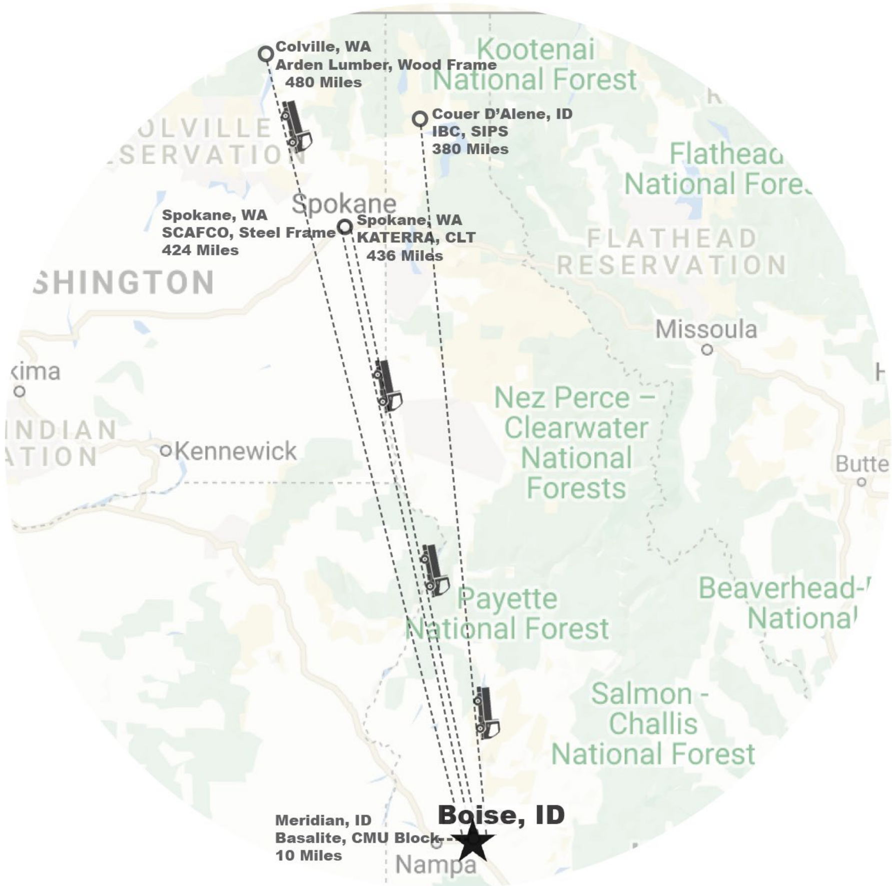
Embodied energy analysis of building materials: An improved IO-based hybrid method using sectoral disaggregation (Manish K. Dixit)

Table of Net Carbon Emissions in Producing a Material

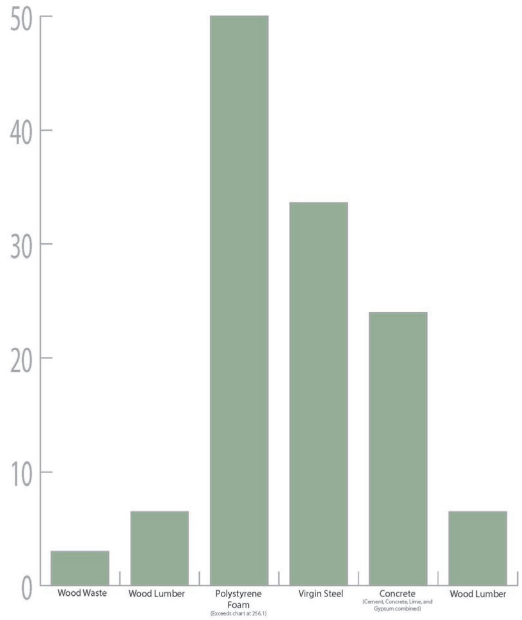
Table 1–3. Net carbon emissions in producing a tonne of various materials

Material	Net carbon emissions (kg C/t)[a,b]	Near-term net carbon emissions including carbon storage within material (kg C/t)[c,d]
Framing lumber	33	–457
Medium-density fiberboard (virgin fiber)	60	–382
Brick	88	88
Glass	154	154
Recycled steel (100% from scrap)	220	220
Concrete	265	265
Concrete[e]	291	291
Recycled aluminum (100% recycled content)	309	309
Steel (virgin)	694	694
Plastic	2,502	2,502
Aluminum (virgin)	4,532	4,532

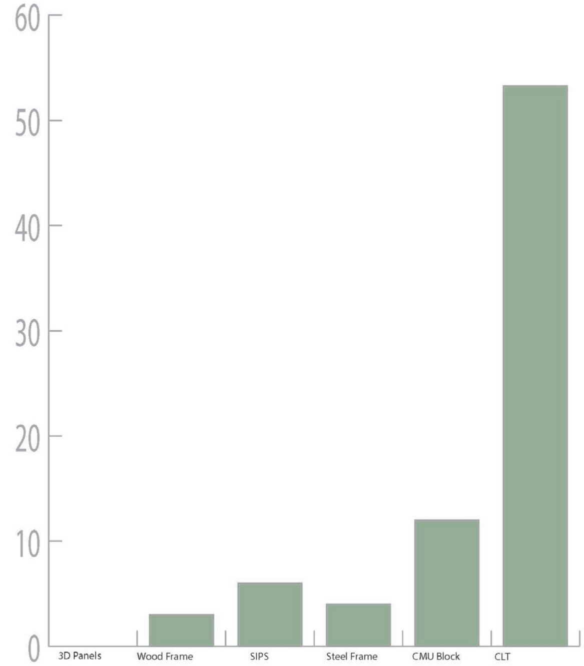
Wood as a Sustainable Building Material Robert H. Falk, Research General Engineer



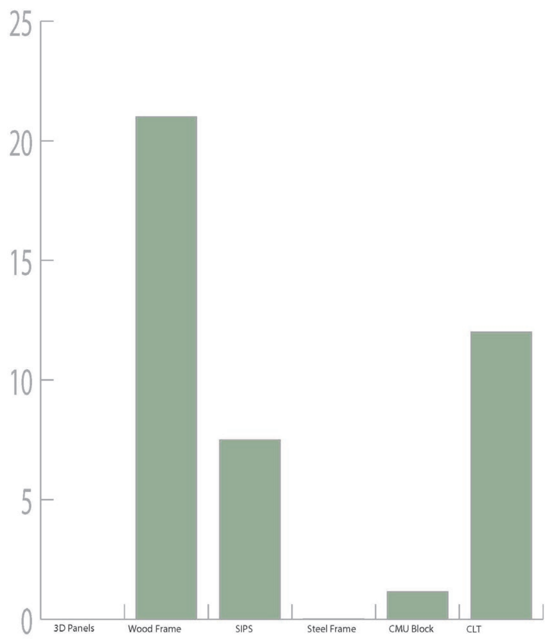
Proximity of Comparable Construction Material Manufacturers



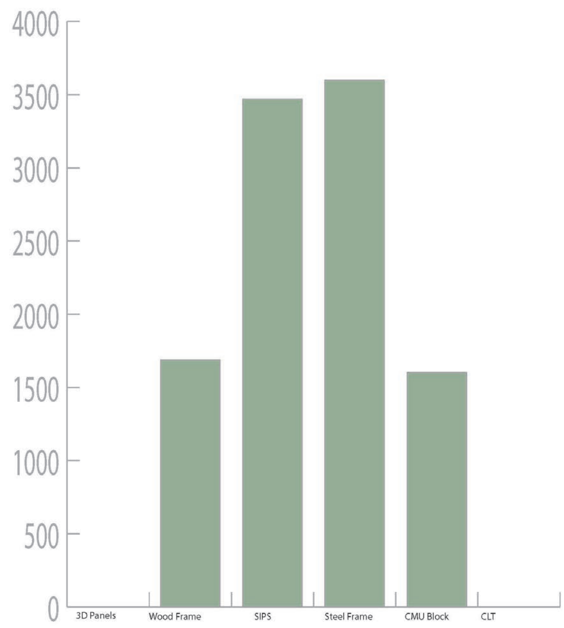
Embodied Energy Ratings using Improved Input-Output Method
(Primary Material Identified and Used)



Approximate Price per Sq Ft



R-Values (BTU/Sq Ft/Degree



Approximate Labor hours for a 10,000 Sq Ft Commercial Building

Environmental Impact

- According to Life Cycle Cost Analysis experts, the most important 'green' aspect of 3D printing is determined by the embodied energy within the base material used for printing.
- The results imply that reducing the amount of raw materials used in production by replacing a large volume object with a post-consumer good that requires little to no processing will dramatically decrease the environmental impact associated with the end product.
- This indicates that distributed manufacturing is technically viable and environmentally beneficial because of both reduced energy consumption and greenhouse gas emissions.
- Potential to completely eliminate the need for a heated platform
- Reduced transport costs and emissions

1. https://pubs.acs.org/doi/pdf/10.1021/sc400093k
2. http://www.ecosmagazine.com/print/EC13276.htm

Environmental Impact of 3D Cold Printed Wood Waste Panels	
Improvements to make 3D Printing Greener	**How our Product and Process addresses these suggestions**
Increase life cycle analysis research	We are using LCA and exploring Embodied energy analysis
Align economic incentives	Examining cost effectiveness as primary factor
Enable lean production	Minimization of waste with panel by panel production
Encourage the use of green materials	Using wood waste
Composting and recycling opportunities	Can be composted or recycled (wood waste)
Decreasing print time//Minimize energy use	Exploring fast curing time with spray nozzle
Decrease use of polymers to be heated	Not using heated bed or nozzle
Eliminate overproduction	Build by necessary amount of panels only
Sustainable material exploration	Utilizing Wood waste as primary material
Repair Potential (extending the life of products after a damaged or worn part is out of production)	Flexibility and durability of panels

Table 5.3. **Priorities for improving environmental impacts of 3D printing**

Focus area	High priority	Medium priority	Low priority
Printer design	**1. Design for minimal idle time (ease of sharing, minimal set-up/clean-up time)** High leverage and simple to implement. **2. Automatic low-power standby** High leverage and simple to implement.	**1. Low-energy printing process (chemical bonding, not melting)** Moderate to high leverage, but requires significant investment and must be combined with energy-efficient equipment systems. **2. Energy-efficient equipment systems (insulation, motors, electronics)** High leverage, but requires significant investment.	**Design software and hardware to minimise material use and waste** High leverage, but market incentives already exert pressure in this direction.
Printing materials	**1. Non-toxic, compostable photopolymers for SLA, DLP, PolyJet, CLIP printers** High leverage and large installed base of photopolymer printers. **2. Improved physical performance/print quality/compostability for existing biopolymers in low-energy print processes** Commercialising existing materials requires less investment than developing new materials.	**Chemical bonding (not melting) of compostable biopolymers, such as MIT's WBDF, for extrusion printers** High leverage, but requires replacing or retrofitting existing extrusion printers (more expensive than simply replacing chemicals in photopolymer printers).	**1. Tunable material properties through printing process, for all printers** Leverage uncertain, still experimental. Could simplify recycling, composting, and toxicity screening, but requires significant investment. **2. Infinitely reusable metal powders produced from recycled material** Probably lower leverage than reducing energy use, and probably requires significant investment.
Printer operations	**1. Sharing printers for more utilisation of fewer machines** High leverage and simple to implement. **2. Optimal bed packing for photopolymer, inkjet, and laser sintering printers** High leverage and simple to implement.	**Minimising support material for all printers** Leverage varies by printer type; implementation can be inexpensive (e.g. improving software algorithms) or expensive (e.g. improving hardware capabilities).	**1. Avoiding failed prints** Leverage varies by application; already strongly incentivised by existing market forces. **2. Hollowing parts for extrusion printers** Leverage varies by application; already strongly incentivised by existing market forces.
IP	**1. Rights for third parties to print replacement parts for products (paying reasonable royalties as needed)** Unclear leverage, but requires only simple legal action with precedent in other industries. No technology development required.		

Source: Authors' analysis.

1. https://www.oecd-ilibrary.org/sites/9789264271036-9-en/index.html?itemId=/content/component/9789264271036-9-en&mimeType=text/html
2. http://www.ecosmagazine.com/print/EC13276.htm

3. Summary of Budget Expenditures

Salaries	Year 1 **$174,900** **$174,900** **Budget**	Through 11/19 (December's actuals not yet posted) **Expended**	**Remaining**
Director/Ken Baker	$12,304	$ 3,626	$ 8,678

Damon Woods	$957	$ -	$ 957
Architecture - RA	$3,022	$ 897	$ 2,125
Engineering RA 1	$17,086	$ 3,231	$ 13,855
Engineering RA 2	$0		$ -
William Basham	$0		$ -
CNR RA (PhD)	$18,659	$ 3,942	$ 14,717
Ralph Budwig	$0		$ -
Tao Xing	$0		$ -
Mike Maughan	$0		$ -
			$ -
			$ -
BSU Contract	$25,535		$ 25,535
			$ -
Tuition			$ -
Architecture - RA	$0	$ -	$ -
Engineering RA 1	$6,670	$ 5,542	$ 1,128
Engineering RA 2	$0	$ -	$ -
CNR RA (PhD)	$11,670	$ 3,350	$ 8,320
			$ -
Travel			$ -
oversight - PI travel in-state	$1,914	$ 500	$ 1,414
Conf. & Industry (out of state)	$0		$ -
Team mtgs BOI->MOS	$3,228	500	$ 3,228
			$ -
Equipment	$73,850	$ 66,000	$ 7,850
Totals	$174,895	$87,088	$87,807

The December actuals have yet to be published. With December accruals we will have spent just over half of the first-year budget.

BSU has been awaiting the U of I contract and, will begin spending in January 2020.

The Rheometer and the analytic computer have been purchased. These were the main pieces of equipment to be purchased in year one. The remaining dollars are for equipment for building the first prototype printer and some supplies for the labs.

4. Demonstration of economic development/impact

- Patents, copyrights
  - None at this time
- Technology licenses signed
  - None at this time
- Private sector engagement
  - We are working with Hexion, a wood adhesive manufacturer out of Oregon. We will begin engaging with potential investors after the end of year one of the grant when the business case is complete.
- Jobs created
  - None at this time
- External funding
  - None at this time
- Other pertinent information
  - None at this time

5. Numbers of faculty and student participation

There are nine faculty participating in the grant, six from the U of I and three with BSU. There are two and one-half Research Associates working on the grant in year one.

6. Description of future plans for project continuation or expansion

Beginning in January 2020, we will continue to work on the three first year objectives; finding a workable printing solution, develop the printer and printer head, and finalize the business case. The Boise State Construction Management team will begin working on the logistics of transport and constructability of the modular panels.

7. Commercialization revenue

None to report. The plan is to begin to commercialize in grant year two, as the business case is developed and investors are then solicited.

[i] Elliott, Blake; Wurtz, Everett; Swift, Nathan; and Manning, Dylan, "Construction Labor Shortage in Idaho: An Examination into the Causes and Consequences" (2017). *2017 Undergraduate Research and Scholarship Conference.*

HERC/IGEM Project

Yr 2: 6 month Progress Report

Project Title: Sustaining the Competitiveness of the Food Industry in Southern Idaho: Integrated Water, Energy and Waste Management

Principal Investigator: Dr. Karen Humes

Institution: University of Idaho (lead) with subcontracts to Boise State University and Idaho State University

Grant Number: IGEM19-001

Award Amount: $700,000

Fiscal Period: July 1, 2019 – June 30, 2020

Progress Report Submitted to SBOE: January 1, 2020

Reporting Period: July 1, 2019 – Dec 31, 2019

Table of Contents

1) Summary of project accomplishments for reporting period and Plans for remainder of Yr 2:

The accomplishments and plans for the four primary tasks identified in the original proposal are summarized here (Tasks A-D). A summary of accomplishments for the overall project management and coordinated stakeholder engagement activities are also summarized below, listed as Task E.

The team would like to stress that our partnerships with producers, processors, municipal treatment personnel and water management entities (private and public) are fundamental to all of our tasks and our project as a whole. Our Yr 2 activities have been influenced and enhanced by interactions with our Stakeholder Advisory Board (described in more detail under Task E below) and interactions with other stakeholders as well.

Task A) Recovery of energy, nutrients, water and bioproducts from waste streams: bench to place-based pilot projects

Team: Erik Coats (UI, environmental engineering/molecular biology; emphasis on resource recovery from waste streams); Armando McDonald (UI, biomass conversion and bioproducts); Kevin Feris (BSU, algae-based resource recovery and microbial ecology))

Team background and overall goals:

This team collaborated for 10+ years and has the required multidisciplinary experience to integrate biological, chemical, physical and thermal approaches to the recovery of energy, bioproducts and nutrients from multiple waste streams. The team is leveraging investments made by the INL, CAES, HERC, and the IGEM incubation fund. Over the last 10 years our efforts have resulted in multiple extramurally funded awards, student training opportunities, scientific publications and a pending patent. We have worked across bench and pilot scales. Recent support from SBOE HERC allowed us to build a pilot scale system to convert dairy waste to value added products (biogas, bio-plastic, algal biomass); previous HERC funding supported construction of two pilot systems at UI by Dr. Coats–one located at the Moscow WWTP, designed for municipal wastewater and one mobile system (24 ft. trailer) designed for dairy manure resource recovery. We are engaged in testing, validating, and extending these systems to evaluate opportunities to recover high-value products (bioplastics, algae, biofuels) from industrial/municipal wastewater while achieving treatment. Research is focused on further understanding/optimizing our integrated system to maximize utility across input streams and demonstrate "real-world" applicability. Research objectives will further technology interrogations and advance wastewater as an economic resource. Ultimately, research will advance solutions that can be applied in Idaho agricultural and food processing sectors; producing economic value from waste will enhance Idaho-based industries by diversifying product portfolios.

Accomplishments this reporting period:

The following provides detail of progress in the first half of Year 2, building from Year 1 successes, towards the aims described in the original proposal.

i. Bench scale: Assess and evaluate nutrient recovery, energy reduction, bioplastics production, and algal production strategies to inform pilot scale operations.

a) Assessment of optimal process sequences (biological, chemical, physical, thermal) to recover energy, bioproducts (biofuels; bioplastics) and nutrients from mixed waste.

- (Coats) Bench-scale bioreactor operations continue to be operated and evaluated. One current focus is analysis of process “success” vs. “failure.” Stable operations of any resource recovery system at full scale demands intrinsic knowledge on what constitutes stable operation, and how unstable, or “failed,” operations might be recovered. Investigations are being conducted using macro- and molecular-level methods.
- (Coats) Phosphorus recovery from wastewater is most sustainably and reliably achieved through a process known as enhanced biological phosphorus removal, EBPR. Bench-scale EBPR operations are ongoing, with a focus on ascertaining the effects of key process operational criteria on maximal P recovery. Building from past research efforts, current investigations are focused on two operational scenarios that integrate a new operational strategy. One operational scenario feeds all wastewater to the bioreactor at one time (beginning of the cycle), while the 2^{nd} strategy feeds a more targeted, controlled wastewater (VFA-rich fermenter liquor) at the beginning of the cycle and then the raw wastewater stream at the end of the anaerobic period. The former operational strategy is identified as the A/O process, while the latter is known as the Westbank process. The central question relates to understanding the effect of adding VFAs outside of the anaerobic period. The new operational strategy employed involves oxidation-reduction (redox) control of the anaerobic period. Research suggests that “deep anaerobic” conditions can enhance and stabilize EBPR; we are utilizing real-time redox process control to further evaluate this operational strategy and its impact on operational “success” vs. “failure.” Results will ultimately inform pilot (2020) and full scale operations.
- (Coats) Another current focus is on achieving stable nitritation in an activated sludge wastewater treatment system achieving carbon, ammonia-N, nitrite-N, nitrate-N, and phosphorus removal. Nitritation is a biological process whereby ammonia-N is oxidized only to nitrite. Process success will result in significant energy savings in wastewater treatment. Process success was realized at both bench and pilot scale in 2019; results are being reviewed to inform 2020 pilot operations.
- Complementing the nitritation research are efforts to understand and better characterize denitritation, with the aim to further optimize the EBPR process for energy efficient nutrient recovery. Nitrate is a contaminant of concern in drinking water, and often must be removed from wastewater prior to discharge to the water environment. A primary concern with conventional EBPR processes that integrate nitrite/nitrate reduction is the potential production of nitrous oxide, which is a very potent greenhouse gas (300X CO_2). Bacteria exhibit variable metabolic pathways to reduce nitrate vs. nitrite; some bacteria cannot reduce nitrate to nitrite, which requires a more complex microbial culture to successfully eliminate nitrate from the wastewater. Ongoing efforts by one of Coats’ PhD students is centered on better understanding the metabolic capabilities of bacteria and how they reduce nitrate vs. nitrite.

- One of Coats' PhD students conducted intense evaluations of the dairy-based PHA pilot in Y1/Y2, with very successful results. Ongoing efforts are focused on finalizing and submitting a peer-reviewed journal manuscript that details the results from these investigations. The manuscript includes numerous team members, including McDonald's research team. Coupled with results from a graduating MS student (funded through other means), plans will be developed in the 2nd half of year 2 to i) execute new bench-scale investigations, and ii) develop plans for summer 2020 pilot scale operations.
- Algal cultivars continue to be used for routine experimental deployment. On-going experiments are focused on cultivation at both bench and pilot scales employing wastewaters from multiple sources (e.g. currently dairy and municipal provided by the Coats lab and the City of Boise) to maximize nutrient capture and algal biomass production. Bench scale experiments are identifying which strains produce optimal levels of biomass under various cultivation conditions. Current bench scale experiments are assessing the utility of municipal sourced struvite to cultivate high value algal biomass under controlled conditions, while simultaneously capturing struvite sourced nutrients (e.g. nitrogen (N) and phosphorus (P)). Specifically, we are testing three algal strains known to produce high concentrations of omega-3 fatty acids under the proper cultivation conditions (i.e. *Chlamydomonas reinhardtii*, *Nannochloropsis oculata*, and *Paeodactylum tricornutum*). These data suggest that certain modifications to the cultivation conditions are required to obtain significant levels of growth when using struvite as the primary nutrient source. These experiments not only direct future work for optimization of algal cultivation on municipal struvite, but are also potentially applicable to struvite produced from agricultural resource recovery systems. As we hone our understanding of what cultivation media factors and growth conditions are required to maximize growth and high value biomass production we will then scaled these experiments up to pilot scales to evaluate high-value algae production at these larger scales.

  Separate cultivation experiments are planned for Fall 2019/Spring 2020 that will pursue mixed-culture approaches for the capture of nutrients from liquid wastewaters. Biomass from these experiments will subsequently provide algae biomass for HTL processing by the McDonald lab. Nutrients captured from the HTL processing of algal biomass will then be tested as inputs to a struvite production system (either via modeling or bench scale struvite production). Struvite produced in this way will then either be tested similar to the municipal struvite experiments described above or analyzed for mineral content to allow accurate estimate of the utility of the algae-capture nutrients purified by struvite production. Based on this suite of experiments we will determine the most appropriate mechanism for algal cultivation and nutrient source in our integrated system. Additional experiments in year 2 and 3 will continue testing of individual or consortia of algal strains previously selected based on their ability to grow in the selected wastewater streams and based on their growth rates, yields, and nutrient capture rates. As noted above these experiments will also be informed by the biomass characteristics and subsequent estimates of economic potential of algae cultivated in struvite that we are currently working towards acquiring. We expect to have some biomass characteristics data acquired during the second half of year 2. However, this effort will continue into year 3.

ii. Pilot scale assessments: Conduct pilot scale evaluations from mixed waste streams; implement/evaluate treatment resource recovery processes.

- Both Coats' pilot systems were made fully operational in Y1, with operations extended into Y2. Coats' research team was fully trained on systems operation.
- Completed hypothetical re-configuration of the Twin Falls wastewater treatment plant to integrate proximate waste streams and achieve resource recovery. Analyses were conducted using SUMO process modeling software by Dynamita. Results will inform Coats' 2020 scale model operations (dairy PHA system; municipal EBPR/nitritation system).
- Completed 2019 operations of Coats' pilot operations at the UI dairy (PHA pilot) and at the city of Moscow, Idaho (EBPR/nitritation pilot). Former efforts were intensively focused on collecting data to facilitate ultimate transition to a full scale system; ongoing data interrogation is informing and being integrated into a journal manuscript. Moreover, PHA pilot data greatly informed potential future scale-up to commercial operations, and the team is evaluating potential new funding opportunities to make the transition to commercialization. Latter efforts focused on preliminary assessment of integrated EBPR-nitritation, with an emphasis on integrating ammonia-based aeration control (ABAC) to enhance nitritation over nitrification. Successful nitritation was achieved for the entire month of August 2019 (early Y2); data evaluation is ongoing, with the aim to inform 2020 pilot operations.
- The initial pilot scale greenhouse systems have been constructed at the Boise State research greenhouse and are being tested for suitability for cultivation of multiple strains. New equipment required for initiation of the greenhouse scale experiments (i.e. a 20L flow through centrifuge) has been purchased and installed in the Boise State greenhouse. Installation and safety checking of the centrifuge has taken longer than expected and has affected the rate of optimization of operational conditions. However, we expect final installation and testing of the centrifuge to be completed by December 2019 and we will initiate greenhouse scale experiments soon thereafter. We expect the proposed greenhouse scale experiments for year 2 to still be completable, however the data collection and analysis may be delayed until the start of year 3. We will do our best to accelerate the rate of these experiments to facilitate our ability to inform decisions about which types of algal cultivation systems to couple with the AD/PHA aspects of our integrated system. Currently, laboratory scale experiments are being utilized to further refine which algal cultivars/species to employ in our greenhouse and pilot-scale tests. We will continue to operate the pilot scale algal cultivation systems through 2020 in collaboration with the Coats and McDonald labs at UI.

iii. Produce prototype products (bioplastic mulch film, biochar, biofuel) for evaluation.

- One PhD student has been working on extracting and isolating pure PHA bioplastic generated from eight trials on the pilot plant over 84 days of operation. Each batch of PHA was produced under slightly different operating conditions (see section ii). The eight batches of the purified PHA bioplastic are being characterized for their thermal and rheological properties in order to determine their suitability for producing bioplastic films.
- With the on-ramping of the greenhouse scale experiments in Fall 2019/Spring 2020 in the Feris lab we will begin to produce suitable quantities of algal biomass for use in HTL

experiments by the McDonald lab. Primary outputs of HTL processing of algal biomass will include biofuel (i.e. biooil), biochar, and aqueous phase nutrients. The aqueous phase will be recycled to the algal cultivation system to enhance algal biomass production.

iv. Partnerships with producers, processors and municipal treatment personnel are fundamental to all of these tasks. Team will build on existing relationships with Twin Falls wastewater treatment facility, Food Northwest, Chobani, Amalgamated Sugar, J.R. Simplot, Idaho Dairymen's Association, and Glanbia, and expand to new partners throughout this project

- We held our initial Stakeholder Advisory Group (SAG) meeting on May 3rd at the University of Idaho Water Center in Boise, Idaho. A primary component of the SAG feedback for the Task A team was to focus on demonstration of commercialize-able product production. We also had a deep conversation regarding the complexities of bringing new systems to market in complex regulatory environments. All of the stakeholders were strongly supportive of the proposed integrated goals of waste treatment and commodity production and pledged to help seek opportunities for the project team to introduce our proposed systems to key commercial partners and operators in the region.

Research plan adjustments in response to our Stakeholder Advisory Group (SAG): During year 1 of our project we had our first stakeholder advisory group (SAG) meeting in May 2019 and our second meeting Dec 2019. These meetings have been very valuable to help fine-tune the trajectory of some of our research tasks and for providing new opportunities to engage with a broader group of potential constituents in the agricultural industry. For example, based on feedback from our SAG the Feris lab adjusted the trajectory of our algal cultivation experiments to encompass studies that address the utility of struvite as a nutrient source for algal cultivation with the idea that these experiments have potential to more quickly develop a process that could become market ready. Additionally, our SAG engagement resulted in leadership from the Idaho Dairymen's Association inviting two members of our team (Feris, Coats) to the joint Idaho/Utah Dairymen's association meeting in Salt Lake City, UT in July 2019. This meeting provided an opportunity to further develop relationships with regional dairy producers and to introduce them to the potential outcomes of our project. Additionally, the Idaho Dairymen's Association networked Coats/Feris with Newtrient LLC (Steve Rowe, CEO). Newtrient is advancing an integrated set of technologies focused on achieving 'net zero' emissions from dairies. Discussions will continue with Newtrient to i) potentially ascertain how the PHA technology might be integrated, and ii) potentially collaborate on future commercialization funding.

One of our goals for year 2 of this project is to continue to build on these budding relationship with the hopes that they will blossom into partnerships for seeking pre-commercialization funding in year 3.

In addition, Dr. Feris will be taking a sabbatical leave during the second half of year 2 and will be dedicating a portion of his sabbatical time to the help forward the Task A team developments towards commercialization. Specific goals will include working to develop relationships with the agricultural industry and local municipalities targeted towards future deployment of our pilot scale systems at potential partner locations in Idaho. Part of this work will include building upon the relationship building initiated during the July 2019 meeting.

Task B) Decision-support tools for industry and community leaders to quantify and visualize trade-offs among water, energy, land use and municipal growth

Team: Jae Ryu, UI, systems dynamics modeling, water resources; Karen Humes (UI, water/energy nexus, geospatial analysis

Overall Goals:

The goal of this task is to integrate energy components into an updated version of a pre-existing system dynamics model for water supply, use and flows in the region of the Eastern Snake Plain Aquifer. The model which will serve as a decision-support tool for stakeholders (including the food producers, food processors, irrigation districts, water and energy providers and municipal communities/citizens). The tool will quantify and provide users with visuals on the linkages between water, energy, land use and municipal growth, to be used for planning and decision-making by producers, water users, businesses, utilities, state agencies and communities.

Accomplishments this period:

- Improved the existing model of water supply/use to better incorporate the specific data needs and what options we can use for conservation scenarios given the existing data types.
- We developed a new graphical user interface based on the newly added Stella Architect modeling platform developed in Yr 1.
- Held a meeting with IDWR regarding their newest ESPAM model version and updated data needs.
- Began exploring management options to incorporate into the model, such as managed aquifer recharge (MAR) option which is the most active management option led by IDWR.
- Evaluated the feedback from IDWR and Surface Water User's Association at the stakeholder meetings in May 2019 and Dec 2019 and how the model could be more useful for stakeholders.
- Began analysis of energy use data associated with irrigation obtained from IDWR in Yr 1
- Further collaboration with experts from Idaho Power on energy use in irrigation in order to further analyze energy use data from across the
- Further evaluation of spatial patterns in energy use for irrigation in the ESPA and controlling factors in order to identify key variables to relate water and energy use in irrigation (i.e., crop type, irrigation system characteristics, water source, etc.)
- Readying the updated Stella Architect model on water use/supply to accept modifications relating water use to energy use.

Plans for remainder of Yr 2:

- Continue incorporating new features that are available in Stella Architect into the system dynamics model and user interface.

- Perform a quality analysis of the most recent data available from IDWR and complete the integration process to bring the model up to date.
- Continue coordinating with IDWR staff to incorporate the new data set from ESPAM version 2.2
- Continue updating management options (e.g., MAR) for stakeholders within Stella Architect modeling platforms to be more useful and help them explore their own management strategies.
- Develop system evaluation criteria associated with new data inputs and potential uses for the expanded and update model, such as system reliability, vulnerability, resilience, etc.
- Incorporate supply side scenarios to address the uncertainty of the water/energy nexus in the Eastern Snake Plain Aquifer (ESPA).
- Increase interaction with the water stakeholder groups to evaluate the ESPA modeling by adding several scenarios of interest from their perspectives, including climate variability and change.
- Offer a short course titled “System dynamics modeling and applications” for UI graduate student, local professionals, and interested groups. Note that this activity is also part of our workforce development tasks (described in Task D).
- Complete the analysis of energy use in irrigation and derive equations to be implemented in the systems dynamics model
- Complete first attempt at adding equations relating water and energy use into the Stella-based Systems Dynamics model of water use/supply.
- Submit draft of journal article describing the linkages between water and energy use in Idaho
- Continue to seek input from our Stakeholder Advisory Board and other water and energy providers, managers and community leaders on how to make the tool/model most useful to them.

Task C) Technical innovations/sensing systems to reduce water/energy/nutrient use in targeted production systems:

Primary team members: Donna Delparte, (ISU, drone and satellite-based sensing systems) and partners among growers and crop consultants.

Accomplishments this period:

Progress in the following task area has been made through the subcontract award to Idaho State University and included:

- **Goal 1 – Decision Support Systems**
    - Decision support online tool prototype for sustainable agriculture decisions making: https://avalanche.geology.isu.edu/i2i/osgood.html
    - This decision support tool was developed by working with stakeholders and our Advisory Board member (Brandon Vining, ProGro) to provide remote sensing data/tools to aid decision making that is relevant to business decision making and operations
    - Stakeholders are excited about the potential of the tool to improve ROI, reduce fertilizer inputs and improve precision farming techniques for sustainable agriculture

- **Goal 2 - Pilot projects to use drone-based, other field-based and satellite sensors to reduce water/nutrient/energy use in production of targeted crops**
  - Conducted remote sensing analysis to forecast yield for potato growers based on a growing season of high-resolution satellite imagery (submitted for publication in 2019 to *ASPRS Pecora Conference Proceedings* by Masters student)
  - Conducted thermal camera surveys of irrigated cropland using UAS in the 2019 growing season irrigation to assess efficiency and support water reduction efforts. Data collected and analysis in progress
  - Hyperspectral camera data collection during the 2019 growing season of potato crops to detect crop threats
  - PhD student conducted experiment to determine essential spectral signatures required to detect individual unhealthy plants in a growers field that leverages machine learning of hyperspectral imagery – thus offering the opportunity to reduce inputs for control and mitigation of disease.
  - Delparte launched a new Idaho based spin-off company (I2IGeo) to provide growers with technological innovations and decision support to assist their operations, leveraging the research outcomes from this grant.

Plans for next reporting period:

For the next reporting period, the team will focus on the continued development and testing of UAS platform and sensor combinations for data collection in the first half of the 2020 growing season, again in partnership with growers and crop consultants. Dr. Delparte will also continue to work actively toward commercialization of the most promising technologies from this research.

Task D) Engaging the present and future workforce in the adoption of new technologies

Team members for training (primary): Karen Humes, Erik Coats, Kevin Feris, and partners at CSI, UI Idaho Falls and professional organizations such as Food Northwest, *Primary team member for drone outreach activities:* Jae Ryu (Idaho Drone League (I-Drone), Founder).

Overall goals:

The overall goals in this task are two-fold: 1) to provide direct support to our stakeholders in the near-term by identifying workforce development needs that universities could plan and implement, together with partners at community colleges and professional organizations (resourced primarily in Yrs 2 and 3) and 2) contribute to longer-term workforce needs by holding outreach events designed to engage the future workforce in STEM activities that will serve the food industry in Idaho in the future, such as drone operations and the analysis of data from sensors onboard drones.

Accomplishments this period:

- Goal 1: Current/near-term workforce development needs
  - Engaged with a stakeholder (IDEQ) that approached us about workforce development needs and added a representative to our Stakeholder Advisory Board

    - Discussion and initial planning for training sessions we could hold in coordination with the rural water treatment association meetings later in Yr 2 and in Yr 3.

- Goal 2:
    - Hosted a hands-on education program known as "Idaho Drone League(iDrone)" to promote STEM pipelines in the Treasure Valley and skills important to the Idaho food industry in the future.

Plans for latter half of Yr 2:

- Training session to be held in May 2019 in conjunction with the Rural Water Treatment association meetings
- Idaho Drone League event to be held in Twin Falls in June 2020. Event will include a table highlighting how drones can be used in food production (from Task C of this research)
- Continue to engage with our Stakeholder Advisory Board and professional organizations such as Food Northwest to identify and implement professional development needs in food, water, energy and waste and how the universities can catalyze and facilitate these.
- Continue to engage with other stakeholders such as the IDEQ on needs and opportunities in professional development on pollution control and management.

Task E) Project Management/Stakeholder Engagement

Background: An important element of our project management was to put together and meet regularly with an advisory board comprised of stakeholders in the food production and processing industries, water user groups and state agencies. In Year 1 we formed this advisory and had a very successful 1st meeting in person in Boise in early May 2019. As noted in the technical progress reports (earlier sections of this report), the board feedback influenced our research plans in Year 2, as planned. The board agreed to meet in it's entirety once/yr in person (Apr/May), once/yr via videoconference (Nov/Dec) and have specialized meetings between specific sub-groups of team and advisory board members in between.

Accomplishments this period:

- We held a 2nd meeting of our full Stakeholder Advisory Board (SAB) on Dec 17, 2019. As planned and discussed at our May meeting, the meeting was held by video, with 4-5 attendees in one conference room in The following SAB members attended and those listed with a (*) were invited and had hoped to attend but were not able to do so:

    - Jeff Bohlscheid, Senior Principal Scientist, J.R. Simplot Company
    - Shawn Moffitt, Regional Business Manager, Jacobs Engineering (contractor for City of Twin Falls and Chobani water treatment plants)
    - Bob Naerebout, Government Affairs and former Exec Director, Idaho Dairyman's Association and and Megan Satterwhite, Environmental Programs Director, IDA
    - Ben Nydegger, Biosolids Program Manager, City of Boise
    - Sean Vincent, Hydrology Section Manager, Idaho Dept of Water Resources

  - Ben Jarvis, Pollution Prevention Projects Coordinator, Idaho Department of Environmental Quality
  - Brian Olmstead*, President, Surface Water Appropriators and General Manager, Twin Falls Canal Company
  - Brandon Vining*, ProGro Consulting

- The primary goal of this second meeting of our SAB was to update the SAB on our previous 6 months activities, particularly those things that had been prioritized or tweaked as a result of their feedback in May, and to gain more insight from them as to how we could make our research as useful to them as possible.
- PI Karen Humes and Co-I Erik Coats met individually with Ben Jarvis in Oct 2019 to discuss workforce training opportunities that could "piggyback" along with existing IDEQ events and/or professional meetings such as the Idaho Rural Water Association
- As described in some detail under our "Task A" Technical progress section above, two of our Co-Is (Coats and Feris) have done considerable outreach to the dairy industry in both Idaho and Utah, including presentations at the Utah Dairyman's Association in July 2019.
- We also established a cloud file storage space for our project (and shared it with the SAB) in which all presentations and notes from our SAB meetings are stored, along with our progress reports to the SBOE/HERC.
- In the way of other team management and organization among Co-Is at the multiple institutions, we have continued our monthly team meetings via videoconferencing.

<u>Plans for next reporting period:</u>

- Hold our spring SAB meeting in Apil or May 2019
- Continue to build on existing relationships with Twin Falls wastewater treatment facility, Food Northwest, Chobani, Amalgamated Sugar, J.R. Simplot, Idaho Dairymen's Association, and Glanbia, and expand to new partners throughout this project
- Continue to hold monthly team meetings to monitor progress and facilitate coordination of all project tasks and stakeholder engagement activities. In coming months these meetings will focus on student presentations of research.

2. Summary of budget expenditures thus far for Yr 1 (July 1, 2019 – June 30, 2020)

A detailed expenditure is provided in Section 6 below, but the table below summarizes the spending in the major budget categories, relative to the budgeted amounts in the original proposal. The expenditure report was run on Dec 18, 2019 and due to delays in invoicing from our partner institutions (primarily) and lag in payroll at the UI, the total expenditure amount now showing ($204,675.21), which translates to a "burn rate" of 29.2% thus far for Yr 2) is considerably less than the actual expenditures at this time. Additionally, our personnel time (both faculty and students) burns at its fastest rate in May/June as many of our faculty and students prepare for and implement field-based research in those months.

Yr 2: IGEM19-001 (Humes) Sustaining the Food Industry in Idaho: Food-Energy-Water-Waste

	Original Budgeted	Expensed 12/18/19		
Salaries:	182481	67732		
Fringe:	25045	8951		
Irregular Help	40000	28946		
Travel:	30000	9830		
OE:	55566	35300		
Participant Support*:				
<$5K Capital:	5500	2522		
>$5K non-capital:	15000	0		
Turstee/Benefits:	58973	23455		
Subawards/contract:	287435	27941		
Total award:	700000	204675	29.2%	Burn rate 12/18/19

*$13,066 budgeted in this category in original proposal will still be expended as indicated in the original budget justification (expenses for team and meetings and professional development events), but was shifted to OE upon budget set-up, per UI OSP advice about appropriate categories for these expenditures.

3. Demonstration of economic development/impact

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

Co-I Dr. Donna Delparte has formed a private company in Idaho and is working to develop a commercialization pathway for her research on this grant related to the use of satellite and drone technology to assist growers in the application of nutrients, herbicides, pesticides and water.

- Private sector engagement

Because every aspect of our work involves considerable private sector engagement, we have noted those engagements in each of our five tasks described in Section 1, particularly under *Task E: Project Management/Stakeholder Engagement.*

- Jobs created

Several of the university staff and all of student research assistantship positions described in the next section were newly created in Year 1 of this grant.

4. Numbers of faculty and student participation

In the first half of Yr 2, the numbers of faculty, students and other researchers participating are as follows:

Faculty:	6	(4 UI, 1 BSU, 1 ISU)
Graduate Students:	9	(6 UI, 3 ISU)
Undergrad Students:	4	(3 UI; 1 BSU)
Research Scientists:	4	(1 UI, 1 ISU, 2 BSU, all partially supported by this grant)

More details on staffing, by Task:

Task A: Recovery of energy, nutrients, water and bioproducts from waste streams

Coats staffing: 2 PhD students in Environmental Engineering; 1 MS student in Environmental Engineering; 2 undergraduate students in Environmental Engineering; 1 undergraduate student in Environmental Science; 1 research scientist. 3 women, 4 men.

McDonald staffing: 1 PhD student in Environmental Science. 1 woman.

Feris staffing: Current staffing includes 2 research technicians and 1 undergraduate research assistant (Spring and Summer 2019) (3 male, all from underrepresented groups in STEM). One of the current lab members (Mr. Alex Torres) is transitioning to the MS graduate program in the Biological Sciences with a Spring 2020 start date. His thesis project will focus on expanding the utility of nutrients and other resources recovered from wastewater for the cultivation of high-value algal biomass. The research technicians and undergraduate students will participate in experimental development, data collection, and data analysis. Additional undergraduate students (1 or 2) will be targeted for recruitment in the second half of year 2 to assist with laboratory and greenhouse scale experiments.

Task B: Quantifying Water/Energy Linkages

- 2 PhD students (1 in Geography, 1 in Water Resources)

Task C:

- 1 PhD students in Geosciences
- 2 summer Masters students in Geoscience
- 1 research/programming technician

5. Description of future plans for project continuation or expansion

- PI Karen Humes is a Co-Lead on the newly formed CAES Focus Area group in the Energy-Water Nexus arena. Being a CAES Focus Area lead provides some access to CAES resources, including program development funds, to build a team of CAES researchers in pursuit of establishing CAES as a global leader in research, education, and innovation related to the energy-water nexus. Team members of this project are looking forward to leveraging our current work to pursue future opportunities. The coupling of food, water and energy is exceptionally strong in southern Idaho, from both a national and international standpoint, making a compelling case for other funding sources. Our integrated approach to water, energy and waste is also unique among teams studying the food-energy-water nexus. She and Co-I Erik Coats organized and attended a workshop at CAES in Idaho Falls on Nov 25, 2019 and are now involved in developing proposals.

- Team members are also actively writing grants to other agencies for related work, such as the NSF, USDA and NASA. This includes a current effort led by PI Karen Humes and involving Co-I

Erik Coats (and 6 other UI faculty) for a graduate student training grant to NSF related to water quality and public health, with emphasis on Idaho (proposal due date Feb 6, 2020). This effort includes also stakeholder partners such as IDWR, IDEQ, and the City of Boise Dept of Public Works.

6. Expenditure reports

The expenditure reports (detailed first, then a summary by category) details the expenditures at the University of Idaho, including the amounts for paid invoices from our two contracting institutions (Idaho State University and Boise State University). Please note that that this report was run on Dec 18, 2019 and due to delays in invoicing from our partner institutions and lag in payroll at the UI, the total expenditure amount now showing ($204,675.21), which translates to a "burn rate" of 29.2% thus far for Yr 2) is less than the actual expenditures at this time. Additionally, our personnel time (both faculty and students) burns at a faster rate in May/June as many of our faculty and students prepare for and implement field-based research in those months.

Detailed Expense Report:

University of Idaho

Itemized Expenditures by Grant Code

From 30-JUN-2019 To 18-DEC-2019

Grant: SG3587 - 18-Dec-2019 01:51 PM

Salaries

E4106 Staff 8707.22

E4108 Summer Salary 8802.00

E4109 IA/GA Salary 50186.00

E4175 Overtime - Covered by FLSA 36.28

$ 67731.50

Temporary/Irregular Help

E4135 Temporary Student 28945.78

$ 28945.78

Fringe Benefits

E4280 Faculty CFR Benefit Expense		2719.82
E4281 Staff CFR Benefit Expense		3541.10
E4282 Student CFR Fringe Expense		2690.49

	$ 8951.41	

Travel

E5360 Personal Vehicle - In-State			
20-SEP-19	I2095733	Ryu, Jae H.	5.00
18-OCT-19	I2101059	Humes, Karen S..	48.09
10-DEC-19	ZT913239	Parking 11112019	10.00
13-DEC-19	I2110710	Ryu, Jae H.	147.69
E5365 Personal Vehicle - Out-of-State			
07-AUG-19	I2087973	Coats, Erik Robert.	42.28
22-OCT-19	I2101614	Coats, Erik Robert.	96.82
22-OCT-19	I2101614	Coats, Erik Robert.	55.00
E5367 Rental Vehicles - In-State			
12-AUG-19	ZT407009	Car Rental Fuel 07202019	60.55
12-AUG-19	ZT407009	Car Rental Fuel 07242019	44.04
12-AUG-19	ZT407009	Car Rental Fuel 07292019	26.72
12-AUG-19	ZT407009	Car Rental Fuel 07302019	37.88
12-AUG-19	I2088874	Ryu, Jae H.	520.99
20-SEP-19	ZT534237	Car Rental Fuel 08102019	27.36
20-SEP-19	ZT534237	Car Rental Fuel 08102019	60.55
20-SEP-19	ZT534237	Car Rental Fuel 08132019	63.74
20-SEP-19	ZT534237	Car Rental Fuel 08142019	27.90

20-SEP-19	ZT534294	Car Rental 09032019	230.06
20-SEP-19	ZT534294	Car Rental Fuel 08302019	64.79
20-SEP-19	ZT534294	Car Rental Fuel 08312019	29.63
20-SEP-19	ZT534294	Car Rental Fuel 09022019	16.02
20-SEP-19	I2095733	Ryu, Jae H.	604.78
20-SEP-19	I2095733	Ryu, Jae H.	53.87
18-OCT-19	I2101059	Humes, Karen S..	181.16
18-OCT-19	I2101059	Humes, Karen S..	2.02
10-DEC-19	I2109969	Humes, Karen S..	252.00
E5380 Airfare - In-State			
18-OCT-19	I2101059	Humes, Karen S..	58.30
18-OCT-19	I2101059	Humes, Karen S..	284.50
10-DEC-19	ZT913239	Airfare 11112019	521.51
E5381 Airfare - Out-of-State			
23-JUL-19	I2085705	Coats, Erik Robert.	478.20
23-JUL-19	I2085707	Coats, Erik Robert.	1280.00
08-OCT-19	I2098846	Ryu, Jae H.	125.00
18-DEC-19	I2111627	Ryu, Jae H.	213.10
E5391 Ground Transportation - In-State			
18-OCT-19	I2101059	Humes, Karen S..	38.00
E5392 Ground Transportation-Out-of-State			
07-AUG-19	I2087973	Coats, Erik Robert.	17.72
22-OCT-19	I2101614	Coats, Erik Robert.	278.80
18-DEC-19	ZT905632	RyuJa 905632 Uber Jae traveled to S	13.95
18-DEC-19	ZT905632	RyuJa 905632 Uber Jae traveled to S	15.26
E5396 Lodging & Per Diem ? In State			
20-SEP-19	I2095776	Ryu, Jae H.	23.00
20-SEP-19	I2095776	Ryu, Jae H.	49.00

20-SEP-19	I2095776	Ryu, Jae H.	49.00
18-OCT-19	I2101059	Humes, Karen S..	26.00
18-OCT-19	I2101059	Humes, Karen S..	42.00
18-OCT-19	I2101059	Humes, Karen S..	42.00
18-OCT-19	I2101059	Humes, Karen S..	33.00
18-OCT-19	I2101059	Humes, Karen S..	30.00
18-OCT-19	I2101059	Humes, Karen S..	164.02
18-OCT-19	I2101059	Humes, Karen S..	433.07
10-DEC-19	I2109969	Humes, Karen S..	26.00
10-DEC-19	I2109969	Humes, Karen S..	49.00
10-DEC-19	ZT913239	Hotel - Lodging 11132019	185.00
10-DEC-19	ZT913239	Hotel - Lodging 11142019	178.71
13-DEC-19	I2110710	Ryu, Jae H.	49.00

E5397 Lodging & Per Diem ? Out of State

22-JUL-19	F0168715	GRT226540-CIVIL&ENV ENGINEERIN	-1526.56
23-JUL-19	I2085705	Coats, Erik Robert.	147.96
24-JUL-19	ZT335285	Hotel - Lodging 07032019	2289.84
07-AUG-19	I2087973	Coats, Erik Robert.	43.00
07-AUG-19	I2087973	Coats, Erik Robert.	56.00
08-OCT-19	ZT599870	Hotel - Lodging 08142019	76.61
08-OCT-19	I2098846	Ryu, Jae H.	37.05
08-OCT-19	I2098846	Ryu, Jae H.	50.00
08-OCT-19	I2098846	Ryu, Jae H.	38.00
22-OCT-19	I2101614	Coats, Erik Robert.	76.00
22-OCT-19	I2101614	Coats, Erik Robert.	76.00
22-OCT-19	I2101614	Coats, Erik Robert.	76.00
22-OCT-19	I2101614	Coats, Erik Robert.	76.00
22-OCT-19	I2101614	Coats, Erik Robert.	76.00

18-DEC-19	I2111627	Ryu, Jae H.	568.54
18-DEC-19	I2111627	Ryu, Jae H.	56.00
18-DEC-19	I2111627	Ryu, Jae H.	56.00
18-DEC-19	I2111627	Ryu, Jae H.	56.00
18-DEC-19	I2111627	Ryu, Jae H.	56.00
18-DEC-19	I2111627	Ryu, Jae H.	33.00

$ 9829.52

Operating Expenses

E5049 Journal Publication Costs

25-SEP-19	ZT574740	Professional Services 09042019	25.00

E5070 Conference/Registration Fees

24-JUL-19	ZT335285	Conference Registration 07012019	615.00
24-JUL-19	ZT335285	Conference Registration 07092019	-570.00
24-JUL-19	ZT335285	Conference Registration 07092019	725.00
24-JUL-19	ZT335285	Conference Registration 07092019	570.00
26-SEP-19	ZT568130	Memberships / Subscriptions / Regis	180.00
01-NOV-19	ZT748634	Memberships / Subscriptions / Regis	-725.00
18-DEC-19	I2111627	Ryu, Jae H.	630.00

E5307 Analytical Services

02-OCT-19	J1252563	MJ/GRC 1811977_Forney	860.00
16-DEC-19	J1260582	bf ASL Invoice EOCT19-003	46.00

E5320 Software/Applications - Individual

27-AUG-19	ZT406541	Supplies 07272019	129.00

E5330 Software/Applications - College/Dep

24-JUL-19	I2086054	Ryu, Jae H.	799.00
14-AUG-19	ZT401299	Supplies 07032019	19.15

14-AUG-19	ZT401299	Supplies 07172019	15.99
12-SEP-19	ZT511342	Supplies 08032019	19.99
12-SEP-19	ZT514946	Supplies 08272019	129.00
E5410 Office and Administrative Supplies			
04-DEC-19	ZT859061	Supplies 11122019	88.34
E5430 Consumable Water			
08-AUG-19	I2088020	Culligan Water Conditioning	29.95
E5465 Gasoline			
14-AUG-19	ZT401299	University Vehicle Expenses 0701201	42.34
14-AUG-19	ZT401299	University Vehicle Expenses 0715201	40.31
E5560 Technology - Supplies			
09-AUG-19	I2088550	Ryu, Jae H.	476.96
04-SEP-19	ZT498840	Supplies 08122019	62.99
30-OCT-19	ZT730095	Supplies 10152019	33.99
E5710 Tools			
14-AUG-19	ZT401299	Supplies 07042019	107.25
14-AUG-19	ZT401299	Supplies 07112019	38.03
E5724 Research Supplies			
18-JUL-19	ZT303097	Supplies 07032019	1613.10
18-JUL-19	ZT303097	Supplies 07052019	11.94
18-JUL-19	ZT303097	Supplies 07062019	98.17
18-JUL-19	ZT303097	Supplies 07072019	11.74
18-JUL-19	ZT303097	Supplies 07092019	396.00
18-JUL-19	ZT303097	Supplies 07092019	18.00
18-JUL-19	ZT303097	Supplies 07102019	166.30
18-JUL-19	ZT303097	Supplies 07112019	91.62
23-JUL-19	I2085701	Ryu, Jae H.	271.08
02-AUG-19	ZT335026	Supplies 07032019	420.44

02-AUG-19	ZT335026	Supplies 07102019	69.54
02-AUG-19	ZT335026	Supplies 07102019	1704.66
02-AUG-19	ZT335026	Supplies 07122019	75.80
02-AUG-19	ZT335026	Supplies 07132019	52.28
02-AUG-19	ZT335026	Supplies 07162019	30.26
02-AUG-19	ZT335026	Supplies 07162019	169.80
02-AUG-19	ZT335026	Supplies 07172019	13.75
02-AUG-19	ZT335026	Supplies 07222019	29.98
02-AUG-19	ZT335026	Supplies 07242019	320.62
02-AUG-19	ZT335026	Supplies 07242019	327.90
02-AUG-19	ZT335026	Supplies 07252019	701.46
07-AUG-19	ZT381455	Agriculture and Medical Supplies 07	18.08
14-AUG-19	ZT401299	Supplies 06262019	5.99
14-AUG-19	ZT401299	Supplies 06272019	94.80
14-AUG-19	ZT401299	Supplies 07022019	92.91
14-AUG-19	ZT401299	Supplies 07022019	9.24
14-AUG-19	ZT401299	Supplies 07082019	39.94
14-AUG-19	ZT401299	Supplies 07112019	189.74
14-AUG-19	ZT401299	Supplies 07142019	217.28
14-AUG-19	ZT401299	Supplies 07192019	156.86
15-AUG-19	ZT402367	Supplies 07192019	61.57
15-AUG-19	ZT402367	Supplies 07272019	69.54
15-AUG-19	ZT402367	Supplies 07272019	48.02
15-AUG-19	ZT402367	Supplies 08012019	53.10
15-AUG-19	ZT402367	Supplies 08012019	185.84
15-AUG-19	ZT402367	Supplies 08022019	-53.10
15-AUG-19	ZT402367	Supplies 08052019	28.45
15-AUG-19	ZT402367	Supplies 08062019	13.94

15-AUG-19	ZT402367	Supplies 08072019	32.44
15-AUG-19	ZT402367	Supplies 08082019	250.82
15-AUG-19	ZT402367	Supplies 08082019	334.67
15-AUG-19	ZT402367	Supplies 08082019	13.98
27-AUG-19	ZT406541	Supplies 07292019	28.93
27-AUG-19	ZT406541	Supplies 07292019	7.41
04-SEP-19	ZT498840	Agriculture and Medical Supplies 08	36.10
04-SEP-19	ZT498840	Supplies 08072019	9.65
12-SEP-19	ZT511342	Supplies 08032019	217.94
12-SEP-19	ZT511342	Supplies 08032019	4.55
12-SEP-19	ZT511342	Supplies 08052019	5.29
12-SEP-19	ZT470567	Supplies 08102019	113.20
12-SEP-19	ZT470567	Supplies 08132019	197.90
12-SEP-19	ZT470567	Supplies 08132019	79.82
12-SEP-19	ZT470567	Supplies 08142019	54.04
12-SEP-19	ZT470567	Supplies 08142019	65.08
12-SEP-19	ZT470567	Supplies 08152019	149.99
12-SEP-19	ZT470567	Supplies 08162019	32.26
12-SEP-19	ZT470567	Supplies 08172019	1046.30
12-SEP-19	ZT470567	Supplies 08182019	1700.00
12-SEP-19	ZT470567	Supplies 08182019	82.51
12-SEP-19	ZT470567	Supplies 08212019	55.97
12-SEP-19	ZT470567	Supplies 08212019	38.35
12-SEP-19	ZT470567	Supplies 08222019	216.16
12-SEP-19	ZT470567	Supplies 08272019	188.66
12-SEP-19	ZT514946	Supplies 08202019	89.90
12-SEP-19	ZT514946	Supplies 08222019	229.00
12-SEP-19	ZT514946	Supplies 08262019	241.38

18-SEP-19	ZT536932	Supplies 09032019	487.72
18-SEP-19	ZT536932	Supplies 09042019	182.70
18-SEP-19	ZT536932	Supplies 09052019	456.23
25-SEP-19	ZT574740	Supplies 09032019	88.77
25-SEP-19	ZT574740	Supplies 09082019	81.80
25-SEP-19	ZT574740	Supplies 09092019	62.95
25-SEP-19	ZT574740	Supplies 09102019	51.94
25-SEP-19	ZT574740	Supplies 09102019	28.39
25-SEP-19	ZT574740	Supplies 09102019	49.69
25-SEP-19	ZT574740	Supplies 09112019	211.89
25-SEP-19	ZT574740	Supplies 09132019	102.25
01-OCT-19	I2097494	Ryu, Jae H.	3120.00
07-OCT-19	I2098295	Culligan Water Conditioning	29.95
07-OCT-19	ZT582328	Supplies 09092019	4.50
07-OCT-19	ZT582328	Supplies 09092019	28.26
07-OCT-19	ZT582328	Supplies 09092019	75.00
07-OCT-19	ZT582328	Supplies 09092019	1.42
07-OCT-19	ZT582328	Supplies 09112019	166.30
07-OCT-19	ZT582328	Supplies 09122019	157.46
07-OCT-19	ZT582328	Supplies 09132019	81.64
07-OCT-19	ZT582328	Supplies 09132019	21.60
07-OCT-19	ZT582328	Supplies 09132019	66.68
07-OCT-19	ZT582328	Supplies 09202019	173.07
07-OCT-19	ZT582328	Supplies 09212019	75.80
09-OCT-19	ZT631422	Supplies 09212019	3244.50
09-OCT-19	ZT631422	Supplies 09242019	283.86
09-OCT-19	ZT631422	Supplies 09272019	2154.25
09-OCT-19	ZT631422	Supplies 09272019	-3244.50

09-OCT-19	ZT631422	Supplies 10012019	17.40
09-OCT-19	ZT631422	Supplies 10022019	396.00
25-OCT-19	ZT638339	Agriculture and Medical Supplies 09	18.50
25-OCT-19	ZT638339	Supplies 09192019	56.82
25-OCT-19	ZT638339	Supplies 09232019	7.40
25-OCT-19	ZT638339	Supplies 09232019	4.79
01-NOV-19	ZT748634	Supplies 10082019	446.27
01-NOV-19	ZT748634	Supplies 10182019	377.25
01-NOV-19	ZT748634	Supplies 10222019	266.80
06-NOV-19	I2103978	Culligan Water Conditioning	29.95
18-NOV-19	ZT811408	Supplies 10282019	70.56
18-NOV-19	ZT811408	Supplies 10292019	41.98
18-NOV-19	ZT811408	Supplies 10302019	147.50
18-NOV-19	ZT811408	Supplies 11012019	187.34
04-DEC-19	ZT900954	Supplies 11042019	8.99
04-DEC-19	ZT900954	Supplies 11072019	6.63
04-DEC-19	ZT900954	Supplies 11132019	461.22
04-DEC-19	ZT900954	Supplies 11152019	1096.36
04-DEC-19	ZT900954	Supplies 11152019	137.09
04-DEC-19	ZT900954	Supplies 11162019	91.62
06-DEC-19	I2109475	Culligan Water Conditioning	29.95
09-DEC-19	J1260116	KRE-H; Phys Mchn shp wrk A McDonald	87.79
11-DEC-19	ZT907694	Supplies 11032019	77.15
11-DEC-19	ZT907694	Supplies 11112019	178.17
18-DEC-19	ZT030436	McDonald A purchased o-rings and co	12.88
18-DEC-19	ZT030436	McDonald, A purchased research supp	40.32
18-DEC-19	ZT852583	McDonald A purchased lab supplies.	24.92
18-DEC-19	ZT852583	McDonald A purchased lab supplies:	6.78

18-DEC-19	ZT852583	McDonald A purchased lab supplies:	13.60
18-DEC-19	ZT852583	McDonald Armando purhcased CHECK IN	254.41
18-DEC-19	ZT852583	McDonald purchased instrument pans	230.00
18-DEC-19	ZT987942	Charge for aluminum dish fluted 144	101.50
18-DEC-19	ZT987942	Charge for high pressure and specia	54.60
18-DEC-19	ZT987942	Charge for new digital ORP sensor,	1123.63

E5741 Med Lab & Tech Supplies

08-JUL-19	U0132495	Chemstores/Alfaro	16.51
10-JUL-19	U0132527	Chemstores/Guho	3.04
10-JUL-19	U0132530	Chemstores/Guho	8.65
24-JUL-19	U0132644	Chemstores/Abbasi	8.18
25-JUL-19	U0132646	Chemstores/Abbasi	30.02
25-JUL-19	U0132647	Chemstores/Abbasi	21.53
26-JUL-19	U0132658	Chemstores/Abbasi	134.58
26-JUL-19	U0132659	Chemstores/Dikshyapokhrel	61.69
07-AUG-19	U0132748	Chemstores/Alfaro	72.00
08-AUG-19	U0132758	Chemstores/McDonald	10.89
13-AUG-19	U0132773	Chemstores/Abbasi	9.91
14-AUG-19	U0132781	Chemstores/Pokhrel	8.18
23-AUG-19	U0132870	Chemstores/Abbasi	214.26
26-AUG-19	U0132881	Chemstores/Pokhrel	9.91
26-AUG-19	U0132882	Chemstores/Pohkrel	29.72
27-AUG-19	U0132894	Chemstores/Abbasi	39.63
29-AUG-19	U0132924	Chemstores/Abbissa	80.97
29-AUG-19	U0132925	Chemstores/Abbisa	61.47
29-AUG-19	U0132926	Chemstores/ReturnU132924	-61.70
03-SEP-19	U0132965	Chemstores/Pokhrel	61.47
04-SEP-19	ZT498840	Agriculture and Medical Supplies 08	30.04

04-SEP-19	ZT498840	Agriculture and Medical Supplies 08	9.90
04-SEP-19	ZT498840	Agriculture and Medical Supplies 08	213.00
04-SEP-19	ZT498840	Agriculture and Medical Supplies 08	43.99
04-SEP-19	ZT498840	Agriculture and Medical Supplies 08	47.17
06-SEP-19	U0133005	Chemstores/Abbasi	91.48
11-SEP-19	U0133072	Chemstores/Abbasi	34.02
13-SEP-19	U0133135	Chemstores/McDonald	23.13
17-SEP-19	U0133169	Chemstores/Abbasi	87.88
17-SEP-19	U0133186	Chemstores/Abbasi	44.84
19-SEP-19	U0133228	Chemstores/Abbasi	72.56
23-SEP-19	U0133262	Chemstores/Guho	9.91
24-SEP-19	U0133284	Chemstores/Guho	25.56
25-SEP-19	U0133296	Chemstores/Abbasi	38.16
02-OCT-19	U0133354	Chemstores/Brower	43.50
03-OCT-19	U0133365	Chemstores/Pokhrel	72.35
22-OCT-19	U0133570	Chemstores/Pokhrell	23.33
25-OCT-19	ZT638339	Agriculture and Medical Supplies 09	105.69
25-OCT-19	ZT638339	Agriculture and Medical Supplies 09	21.98
25-OCT-19	ZT638339	Agriculture and Medical Supplies 09	178.08
25-OCT-19	ZT638339	Agriculture and Medical Supplies 09	299.99
25-OCT-19	ZT638339	Agriculture and Medical Supplies 09	17.65
25-OCT-19	ZT638339	Agriculture and Medical Supplies 09	226.85
04-NOV-19	U0133705	Chemstores/Abbasi	23.73
21-NOV-19	U0133885	Chemstores/Pokhrel	30.00
E5747 Safety Supplies			
25-SEP-19	ZT574740	Supplies 09022019	21.18
E5910 Rent - Machinery & Equip			
28-AUG-19	I2091615	Culligan Water Conditioning	29.95

E5940 Other Rentals and Leases

20-AUG-19 I2090470 Boise State University 337.50

E5992 Promotion

02-DEC-19 J1259868 Bkstr;TABLECLOTH CALS 188.00

$ 35299.85

Subawards

ES001 Subaward 1 Expenses

28-OCT-19 I2102349 Boise State University 27940.93

$ 27940.93

Small Equipment (<$5K)

E7830 <5K Computer Equipment Other

16-JUL-19 I2084671 Ryu, Jae H. 1324.98

E7995 <5K Communication Equipment

06-NOV-19 I2104173 Ryu, Jae H. 1196.74

$ 2521.72

Tuition Remission and Training

E7140 Tuition and Fees - Grad Assistants

16-AUG-19 J1251999 G1GB for 171-55579 786.00

16-AUG-19 J1251999 SHI1 for 171-55579 951.00

16-AUG-19 J1251999 T1GB for 171-55579 4152.00

21-AUG-19 J1252645 G1GB for V00665494 786.00

21-AUG-19 J1252645 GP01 for V00665494 48.50

21-AUG-19	J1252645	SHI1 for V00665494	951.00
21-AUG-19	J1252645	T1GB for V00665494	4152.00
21-AUG-19	J1252645	VVSF for V00665494	100.00
22-AUG-19	J1252827	G1GD for 142-24168	786.00
22-AUG-19	J1252827	SHI1 for 142-24168	951.00
22-AUG-19	J1252827	T1GD for 142-24168	4152.00
03-SEP-19	J1253572	G1GA for 941-68901	596.00
03-SEP-19	J1253572	G1GB for 051-04535	786.00
03-SEP-19	J1253572	T1GB for 051-04535	4152.00
22-OCT-19	J1257016	AN01 for 051-04535	105.00

$ 23454.50

Total Expenses $ 204675.21

Expenditures Summarized by Category:

University of Idaho

Itemized Expenditures by Grant Code

From 30-JUN-2019 To 18-DEC-2019

Grant: SG3587 - 18-Dec-2019 01:51 PM

Salaries

E4106 Staff	8707.22
E4108 Summer Salary	8802.00
E4109 IA/GA Salary	50186.00
E4175 Overtime - Covered by FLSA	36.28

	$ 67731.50

Temporary/Irregular Help

E4135 Temporary Student	28945.78

	$ 28945.78

Fringe Benefits

E4280 Faculty CFR Benefit Expense	2719.82
E4281 Staff CFR Benefit Expense	3541.10
E4282 Student CFR Fringe Expense	2690.49

	$ 8951.41

Travel

E5360 Personal Vehicle - In-State	210.78
E5365 Personal Vehicle - Out-of-State	194.10
E5367 Rental Vehicles - In-State	2304.06
E5380 Airfare - In-State	864.31
E5381 Airfare - Out-of-State	2096.30
E5391 Ground Transportation - In-State	38.00
E5392 Ground Transportation-Out-of-State	325.73
E5396 Lodging & Per Diem ? In State	1378.80
E5397 Lodging & Per Diem ? Out of State	2417.44

	$ 9829.52

Operating Expenses

E5049 Journal Publication Costs	25.00
E5070 Conference/Registration Fees	1425.00
E5307 Analytical Services	906.00
E5320 Software/Applications - Individual	129.00
E5330 Software/Applications - College/Dep	983.13
E5410 Office and Administrative Supplies	88.34
E5430 Consumable Water	29.95
E5465 Gasoline	82.65
E5560 Technology - Supplies	573.94
E5710 Tools	145.28
E5724 Research Supplies	27699.23
E5741 Med Lab & Tech Supplies	2635.70
E5747 Safety Supplies	21.18
E5910 Rent - Machinery & Equip	29.95
E5940 Other Rentals and Leases	337.50

E5992 Promotion 188.00

$ 35299.85

Subawards

ES001 Subaward 1 Expenses 27940.93

$ 27940.93

Small Equipment (<$5K)

E7830 <5K Computer Equipment Other 1324.98

E7995 <5K Communication Equipment 1196.74

$ 2521.72

Tuition Remission and Training

E7140 Tuition and Fees - Grad Assistants 23454.50

$ 23454.50

Total Expenses $ 204675.21

7. Commercialization revenue - None to report at this time, however, Dr. Delparte (ISU) is actively working on the development of commercialization pathways from the research being done under Task C and Dr. Feris will be working in the latter half of Yr 2 to explore commercialization pathways for aspects of the research being done under Task A.

Appendix A: Project Brochure Prepared for Stakeholder Engagement

WATER, ENERGY, and WASTE Management

for FOOD PRODUCTION, PROCESSING, and RESOURCE RECOVERY

WHO we are: Consortium of scientists and engineers from University of Idaho, Boise State University, Idaho State University, and Center for Advanced Energy Studies

University of Idaho

BOISE STATE UNIVERSITY

Idaho State UNIVERSITY

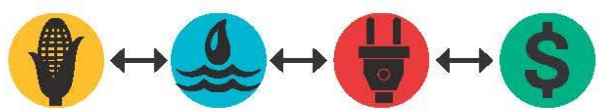
CAES Center for Advanced Energy Studies

WHY ARE WE ASKING YOU TO
ENGAGE WITH US?

- You are among the leaders in Idaho food production, processing, and associated services such as water and waste treatment
- To gain your perspective and input on issues, challenges, and pathways for your industry
- To better understand both single-user solutions and longer-term visions for applied research on regional solutions, including efficiencies to be gained through collaboration.
- To learn about workforce preparedness gaps and how we can help fill them

WHAT we are:

- Team conducting applied research funded by Idaho State Board of Education
- Research activities focused on creative solutions in water, energy, and waste management that enhance economic and environmental bottom line for Idaho agro-industry and rural communities.



TEAM EXPERTISE -
FOR DAIRIES AND FOOD PROCESSING:

- Wastewater treatment: operations,energy efficiency, nutrient recovery, and water recycling
- Minimizing management of waste products or any other outputs parasitic to the economic bottom line
- Assisting stakeholders to diversify economic portfolio via resource recovery and retrieval of other value-added products

TEAM EXPERTISE -
FOR CROP PRODUCTION:

- Tools for utilizing satellite and drone data for optimal application of nutrients and water

TEAM EXPERTISE -
FOR ALL STAKEHOLDERS, INCLUDING STATE AND COUNTY/MUNICIPAL PLANNING:

- Quantifying the interconnection of water, energy, and waste streams in southeastern Idaho region
- Useful for planning and identifying synergies/ partnerships among stakeholders in the future

For more information, please contact Project Director Karen Humes, *khumes@uidaho.edu* or 208-885-6506.

Cover Sheet

Ink Production Scale-Up

Semi-Annual Report

Reporting Period: Jul 1st, 2019 — Feb 1st, 2020

Technical Point of Contact

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1. Summary of Project Accomplishments and Plans

1.1 Accomplishments for this report period

Although the HERC project started on July 1, 2019, the PI did not have access to the funds until September 13, 2019 when the account was set up by the Office of Sponsored Projects at Boise State. This report covers the activities performed since September 13, 2019 until February 1, 2020.

Milestone Achievements

- Hired undergraduate student, Ms. Jasmine Cox, to work on ink synthesis and printing.
- Hired Post-Doc Dr. Josh Eixenberger (15% effort) to work on ink volume scale-up.
- Ordered and received microviscometer to measure the viscosity of material inks being formulated in the Advanced Nanomaterials and Manufacturing Laboratory (ANML).
- Placed an order for a Tangential Flow System to help scale up ink production.
- Ink 1: Started working on ZnO (Zinc Oxide) inks since there is an immediate interest from NASA and Boeing in getting this ink from us. These inks will be the first to be commercialized from partner, INFlex Labs, LLC.
- Ink 2: Worked on formulating Nickel ink and testing its performance. Nickel ink will also be commercialized through the company. Oak Ridge National Lab is an immediate customer.

1.2 Plans for the next reporting period

During the next reporting period, we plan to

- Fine tune the inks and processing parameters so that we can demonstrate compatibility and printability with the printer suite we have at Boise State. This will help create a datasheet for the different inks being formulated, and help the company market the ink to potential customers.
- Demonstrate the synthesis of higher volumes of inks so that the ink manufacturing could be made commercially viable. The Tangential Flow System will be set up specifically for this purpose.
- Develop a business plan together with the company. We will approach potential customers with prototypes and samples. We have already identified a few customers, including NASA Ames, Boeing Corporation, and Oak Ridge National Lab.

2. Summary of Budget Expenditures for the Period Just Completed

<u>Expenditure from Boise State University: $50,696.53 to date</u>

During this reporting period, we spent $50,696.53 overall. Within this, two pieces of equipment were purchased – (1) a RheoSense Microviscometer to measure the viscosity of ink synthesized ($9,977.40) and (2) a Tangential Flow System to help scale up the ink volume ($21,150). The remainder was spent to cover the salaries and fringe of the undergraduate student and the post-doc. Expenses were also incurred for the printer use in the cleanroom and for ink characterization.

3. Number of Faculty and Student Participation Resulting from Funding

This project has had participation from one faculty member – Prof. Harish Subbaraman (PI), one undergraduate student, Ms. Jasmine Cox, and one post-doc, Dr. Josh Eixenberger. This project is providing hands-on ink synthesis and printing experience to the undergraduate student, and furthering the expertise of the post-doc who is skilled in the synthesis of nanoparticles and nanoparticle inks

4. Patents, copyrights, and plant variety protection certificates received or pending

While there is still great potential, as yet, there has been no idea or new technology reviewed on this project during this first time period that has led to any specific or particular new intellectual property.

5. Technology licenses signed and start-up businesses created

We have seen great interest from industry and national labs in trying to learn more about the project and procuring inks and associated processing information from us. Boise State and INFlex Labs are working on signing an agreement related to commercialization of the inks.

6. Status of private part/industry partnerships

PI Subbaraman received a NASA EPSCoR and NSF Nanomanufacturing awards. The incubation fund will enable setting up of state-of-the-art equipment for ink production scale-up. The EPSCoR grant will look into flexible electronic device development integration using a plasma jet printer for space applications. Currently, there are no ink vendors for the plasma jet tool, thus placing INFlex and Boise State in a very good position to work with the equipment manufacturer and promote our inks. The successful outcome from the current HERC project will lead to direct investment from interested companies and investors.

7. Additional Funding Received and Financial Burn Rate

As mentioned above, the PI has several other projects that utilize inks for developing flexible electronic devices and sensors. The work that will be performed in this project will be a natural extension of accomplishments in those projects. The PI is also constantly trying to secure extramural funding in this area, and we foresee efforts beyond the IF project going into further development of inks, sensors, and devices that can be used in the food storage, consumer electronics, space, and other markets.

In terms of financial burn rate, we will be using the remainder of funds on ink production, ink characterization, and development of processing recipes on the commercial printing tools at Boise State.

Report for IF20-001

Summary

Accomplishment: In the last 6 months , the PO for SHG One laser system from Spectra Physics was successfully sent out from the university. There was a delay in purchasing due to legal and contractual obligations on both the company and university. The PO was sent out in the beginning of January. The entire budget of the incubation fund was used towards this purchase along with a cost match from the PI.

Plan forward:

In the next 6 month we plan to accomplish the following tasks

Task 1: Set up the laser system: The laser has a 3 month lead time. We plan to have the laser installed in the beginning of May.

Task 2: Set up the optical fabrication set up: We will set the fabrication set up for this system. We believe this will be done by Mid May

Task 3: Fabricate the sensors and testing: The fabrication of the sensors both, based on conventional Fiber Bragg Grating design and the designed Long Period Grating sensors will be fabricated on optical fibers and their performance will be characterized. We project the first sensor to be fabricated in the beginning of June and tested by mid June.

Summary of budget expenditure

Entire budget has been encumbered through the PO to Spectra physics

Number of faculty and student participation

Currently, Faculty participation: 1

Anticipated graduate student participation : 1

Patents, copyright received

None

Status of industry partnership

Fiberguide is currently waiting for the laser system. The PI and the company will leverage this instrument to submit a followup grant to NSF-COBRE.

DARWINS' DEMONS MOBILE: EXPANDING THE MARKET FOR EVOLUTIONARY PROCEDURAL CONTENT GENERATION.

PROGRESS REPORT: Grant Number IF20-003
PRINCIPAL INVESTIGATOR: Barrie Robison
REPORTING PERIOD: July 1, 2019 – January 1, 2020

SUMMARY OF PROJECT ACCOMPLISHMENTS:

Hired lead artist and game developer (Landon Wright).

Hired development team:
Programmers: Lily Mason and Graeme Holliday
Music and Sound: Parker Piedmont
Interface and 2D Art: Aaron Yama
Marketing and Social Media: Savanna Estey

Developed "Darwin's Demons Moblie" into a playable beta stage. The game is a space shooter that features evolving opponents that are procedurally generated. We can provide copies of the game for Android or Apple devices. The game features 5 ships, more than 25 pieces of equipment, 2 maps, and a soundtrack that evolves along with the enemy population.

Registered with Google Play store for sale.
Registered with Apple App store through the UI's account.

Developed the microtransaction business model and are now incorporating it into the game's architecture.

PLANS FOR THE NEXT REPORTING PERIOD:

Integrate game store page into the software (this task is close to completion).

Continue to beta test and refine the game mechanics.

Build out additional maps

Develop store pages on Google Play and Apple App store.

Release the game on Google Play and App Store with a staggered release strategy. This will allow us to deal with post release bug fixes one platform at a time.

Begin and sustain an advertising and promotion campaign.

SUMMARY OF BUDGET EXPENDITURES:

As of Feb 1, 45.95% of our funds remain. We are on track with regard to our spending projections, as the burn rate for the 2D artist position will increase to 10 hours per week.

Detailed reports of our expenditures are attached.

FACULTY AND STUDENT PARTICIPATION:

One staff (artist/game developer) and five students were directly supported by grant funds during the reporting period. Drs. Barrie Robison and Terry Soule are the primary faculty, but we collaborate with colleagues from Education (3), English (1), VTD (3), Music (1), and Business (1).

Total Student Participants: 5
Total Faculty Participants: 11
Total Staff Participants: 1

PATENTS, COPYRIGHTS, AND CERTIFICATES:

None, but we will file a disclosure with our office of Tech Transfer prior to completion of the grant.

LISCENSES AND START-UP BUSINESSES:

Should the game sales perform well, we will create an LLC.

INDUSTRY AND PRIVATE PARTNERSHIPS:

None (yet).

ADDITIONAL FUNDING AND BURN RATE:

Our burn rate is described in the attached financial statements.

We have applied for a $1.5 million grant from the National Institutes of Health with our colleagues from the College of Education. We are also working on additional proposals for future games that would be licensed to the LLC if formed.

ADDITIONAL INFORMATION:

None.

dget Status

		Total Budget	Total Expenses	Commitments	Available Balance	% Remaining

3979 Research Centers and Institutes

Grant Code: CB3911 - ISBOE Darwin's Demos Mobile
PI Name: Robison, Barrie
F&A Rate: 0

Grant Start: 7/1/2019
Grant End: 6/30/2020
% Time Remaining: 39.33

Fund Level 2: 222 Other
Fund: 223911 ISBOE Darwin's Demos Mobile
Index: 897803 ISBOE Darwin's Demos Mobile
Orgn: 897 Initiative for Bioinfo & Evol Study

		Total Budget	Total Expenses	Commitments	Available Balance	% Remaining
10-SALARY		53,939.00	15,793.60	9,812.05	28,333.35	52.53
11-FRINGE		16,789.00	6,632.74	0.00	10,156.26	60.49
12-IRRHELP		0.00	6,949.50	0.00	(6,949.50)	0.00
30-OP EXP		3,972.00	1,187.28	0.00	2,784.72	70.11
Fund: 223911	**Total**	74,700.00	30,563.12	9,812.05	34,324.83	45.95
Grant: CB3911	**Total**	74,700.00	30,563.12	9,812.05	34,324.83	45.95
	Total	74,700.00	30,563.12	9,812.05	34,324.83	45.95

Grant Code	CB3911
Fiscal Period	(All)

Row Labels		Sum of YTD
10		**11849.92**
Salaries		**11849.92**
10		0
Salaries		**0**
sm setup		0
J1252954		0
E4106		11849.92
Staff		**11849.92**
Encumbrance Salaries	(Adj)	0
F0172118		0
F0173015		0
F0174360		0
F0175336		0
F0176268		0
F0177255		0
F0178372		0
Encumbrance Salaries	(Orig)	0
F0171342		0
HR Payroll 2019 UI 19 0		1481.24
F0171347		1481.24
HR Payroll 2019 UI 20 0		1481.24
F0172121		1481.24
HR Payroll 2019 UI 21 0		1481.24
F0173018		1481.24
HR Payroll 2019 UI 22 0		1481.24
F0174273		1481.24
HR Payroll 2019 UI 23 0		1481.24
F0175339		1481.24
HR Payroll 2019 UI 24 0		1481.24
F0176271		1481.24
HR Payroll 2019 UI 25 0		1481.24
F0177259		1481.24
HR Payroll 2019 UI 26 0		1481.24
F0178375		1481.24
11		**4989.87**
Fringe Benefits		**4989.87**
11		0
Fringe Benefits		**0**
sm setup		0
J1252954		0
E4281		4799.21
Staff CFR Benefit Expense		**4799.21**
HR Payroll 2019 UI 19 0		599.9

F0171349	599.9
HR Payroll 2019 UI 20 0	599.9
F0172123	599.9
HR Payroll 2019 UI 21 0	599.9
F0173020	599.9
HR Payroll 2019 UI 22 0	599.9
F0174275	599.9
HR Payroll 2019 UI 23 0	599.9
F0175341	599.9
HR Payroll 2019 UI 24 0	599.9
F0176273	599.9
HR Payroll 2019 UI 25 0	599.9
F0177261	599.9
HR Payroll 2019 UI 26 0	599.91
F0178377	599.91
E4282	190.66
Student CFR Fringe Expense	**190.66**
HR Payroll 2019 UI 20 0	3.95
F0172123	3.95
HR Payroll 2019 UI 21 0	24.1
F0173020	24.1
HR Payroll 2019 UI 22 0	33.03
F0174275	33.03
HR Payroll 2019 UI 23 0	37.24
F0175341	37.24
HR Payroll 2019 UI 24 0	32.78
F0176273	32.78
HR Payroll 2019 UI 25 0	21.81
F0177261	21.81
HR Payroll 2019 UI 26 0	37.75
F0178377	37.75
12	**5606.25**
Temporary Help	**5606.25**
E4135	5606.25
Temporary Student	**5606.25**
HR Payroll 2019 UI 20 0	116.25
F0172121	116.25
HR Payroll 2019 UI 21 0	708.75
F0173018	708.75
HR Payroll 2019 UI 22 0	971.25
F0174273	971.25
HR Payroll 2019 UI 23 0	1095
F0175339	1095
HR Payroll 2019 UI 24 0	963.75
F0176271	963.75
HR Payroll 2019 UI 25 0	641.25
F0177259	641.25

HR Payroll 2019 UI 26 0	1110
F0178375	1110
30	**777.3**
Other Expense	**777.3**
30	0
Other Expense	**0**
sm setup	0
J1252954	0
E5330	750
Software/Applications - College/Dep	**750**
Supplies 08302019	250
ZT722470	250
Supplies 09302019	250
ZT722470	250
Supplies 10302019	250
ZT850594	250
E5560	27.3
Technology - Supplies	**27.3**
Supplies 10222019	27.3
ZT850594	27.3
RV	**23223.34**
Revenue	**23223.34**
R3731	23223.34
Grants & Contracts - State	**23223.34**
HR Payroll 2019 UI 19 0	2081.14
F0171347	1481.24
F0171349	599.9
HR Payroll 2019 UI 20 0	2201.34
F0172121	1597.49
F0172123	603.85
HR Payroll 2019 UI 21 0	2813.99
F0173018	2189.99
F0173020	624
HR Payroll 2019 UI 22 0	3085.42
F0174273	2452.49
F0174275	632.93
HR Payroll 2019 UI 23 0	3213.38
F0175339	2576.24
F0175341	637.14
HR Payroll 2019 UI 24 0	3077.67
F0176271	2444.99
F0176273	632.68
HR Payroll 2019 UI 25 0	2744.2
F0177259	2122.49
F0177261	621.71
HR Payroll 2019 UI 26 0	3228.9
F0178375	2591.24

F0178377	637.66
Supplies 08302019	250
ZT722470	250
Supplies 09302019	250
ZT722470	250
Supplies 10222019	27.3
ZT850594	27.3
Supplies 10302019	250
ZT850594	250
Grand Total	**46446.68**

2019
CAES ANNUAL REPORT

October 1, 2018 - September 30, 2019

CAES Center for Advanced Energy Studies

On the cover: A data set displayed in CAES' Applied Visualization Laboratory
Photo credit: Chris Morgan, INL

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Director's Letter

2019 was a momentous year here at CAES, one in which we commemorated the 10th anniversary of our Idaho Falls headquarters, welcomed our 15,000th visitor, and celebrated CAES Day in the State of Idaho.

CAES' first decade was loaded with milestones, and we intend to continue on that track as we harness the power of collaboration among our members to address complex global energy challenges and train the next generation of scientists, engineers, and researchers.

We began implementing the new CAES strategy this year in order to accomplish this. With its focus on collaborative research, education, and innovation, our reinvigorated approach has already begun bearing fruit.

In July, for example, a collaborative effort among Idaho State University and Idaho National Laboratory received an award of almost $1.1 million from the Idaho Global Entrepreneurial Mission (IGEM) grant program initiative. The project calls for the construction of a disaster response complex for first responders and is led by Dr. Mustafa Mashal, a CAES faculty member from Idaho State University who received seed funding to develop the project from CAES and first met his INL collaborators at a CAES workshop.

CAES will also be involved in INL's partnership with NuScale in building the world's first small modular reactor thanks to a grant from the Department of Energy's Nuclear Energy University Program that will support the installation of a NuScale reactor control room simulator at CAES. The grant to University of Idaho Professor Rich Christensen's team will allow CAES to train students on nuclear power plant behavior and expand CAES' research efforts, K-12 outreach, and public education regarding nuclear power and the technology behind small modular reactors.

Several CAES researchers garnered national recognition for their work in 2019, including Dakota Roberson, a CAES-affiliated Assistant Professor at University of Idaho who was selected for the prestigious White House Fellows program. Dave Estrada, the CAES Associate Director for Boise State University, and CAES-affiliated Boise State Professor Hoda Mehrpouyan received prestigious CAREER Awards from the National Science Foundation. Mehrpouyan's $454,000 award will support her work combatting cyber attacks on critical infrastructure such as water treatment plants. Estrada's award of more than $550,000 will enable research in the CAES focus area of advanced manufacturing and could revolutionize human tissue engineering.

In September, CAES made its presence known globally as the CAES Energy Policy Institute's annual Energy Policy Research Conference drew international attendees. And we made our mark in the nation's capital in March, when I had the honor of testifying before the US House Appropriations Subcommittee on Energy and Water Development concerning CAES' innovative efforts to develop the energy workforce of the future.

This year also saw the completion of the first full year of the CAES Summer Visiting Faculty program, which created 18 new partnerships between faculty at the CAES universities and INL researchers.

And just recently, we formed working groups in each of the CAES focus areas outlined in the strategy. These seven groups will catalyze researcher-driven deepdives into projects made possible through collaboration and serve as catalysts for sharing and leveraging the expertise, capabilities, and resources across the five CAES entities. These groups will ultimately serve as a force multiplier, allowing CAES to tackle complex global energy challenges and fulfill our vision of creating a better energy future through collaboration that inspires energy leadership, ignites technology innovation, and catalyzes global impact.

Finally, Idaho Governor Brad Little closed out the year by declaring October 1, 2019, as CAES Day in Idaho in commemoration of the facility's 10th anniversary. We are now looking forward to the next 10 years and a declaration of The Decade of CAES!

There is ample work to be done, and we are eager to get started. First, though, we hope you enjoy this annual report and the opportunity it provides to reflect on what we accomplished together in 2019 – from patents to proclamations, projects to partnerships.

There's much to do as we embark on our next decade, so let's get to it.

In collaboration,

Noël Bakhtian
CAES Director

CAES Center for Advanced Energy Studies

Executive Department
State of Idaho

The Office of the Governor

Proclamation

State Capital
Boise

WHEREAS, the Center for Advanced Energy Studies (CAES) is a research, education, and innovation consortium bringing the Idaho National Laboratory (INL) together with the public research universities of Idaho and Wyoming, including Boise State University, Idaho State University, University of Idaho, and University of Wyoming; and

WHEREAS, CAES' vision is to create a better energy future through collaboration that inspires energy leadership, ignites technology innovation, and catalyzes global impact; and

WHEREAS, CAES' mission is to inspire innovation and impact by leveraging collective capabilities to empower students, researchers, faculty, and industry to accelerate energy solutions; and

WHEREAS, CAES was conceived as a catalyst, activating world-class research assets at INL in combination with students and faculty at the universities to solve complex energy challenges while providing hands-on experience and mentorship that leads to valuable future career opportunities; and

WHEREAS, CAES is committed to conducting cutting-edge energy research, educating the next generation of scientists and engineers, and partnering with industry to advance competitiveness; and

WHEREAS, CAES focuses its efforts in the areas of nuclear energy, energy-water nexus, cybersecurity, advanced manufacturing, innovative energy systems, energy policy, and computing, data, and visualization; and

WHEREAS, CAES members have received more than $100 million in competitive grants and generated more than 1,700 publications, while inspiring the next generation by hosting more than 15,000 visitors; and

WHEREAS, CAES is a force multiplier created to spur collaboration for the greater good; and

WHEREAS, CAES over the last 10 years has served the State of Idaho and its residents with distinction;

NOW, THEREFORE, I, BRAD LITTLE, Governor of Idaho, do hereby proclaim October 1, 2019, to be

CENTER FOR ADVANCED ENERGY STUDIES (CAES) DAY

in Idaho.

IN WITNESS WHEREOF, I have hereunto set my hand and caused to be affixed the Great Seal of the State of Idaho at the Capitol in Boise on this 1st day of October, in the year of our Lord two thousand and nineteen and of the Independence of the United States of America the two hundred forty-fourth and of the Statehood of Idaho the one hundred thirtieth.

BRAD LITTLE
GOVERNOR

LAWERENCE DENNEY
SECRETARY OF STATE

BY THE NUMBERS

Through collaboration, CAES members leverage the following collective assets:

8,000 More than 8,000 scientists, engineers, faculty, and support staff

65,000+ More than 65,000 students

1,100 More than 1,100 degrees and certificates offered

100 Nearly 100 laboratories and engineering facilities

$1.8B Approximately $1.8 billion in annual research funding

Investments

$5Million Idaho National Laboratory investments in CAES

$3Million State of Idaho investments in CAES

Outreach

2,116
visitors to CAES and the CAVE 3D immersive research environment

68
working meetings, seminars, and speeches hosted or sponsored by CAES

197
CAES publications and proceedings

Research and Program Funding

~$1.086M
Funding to CAES member faculty through DOE's Nuclear Energy University Program (primary award)

~$1.3M
Funding to CAES member faculty through DOE's Nuclear Energy University Program (partner award)

$5M
FY2019 Laboratory Directed Research and Development (LDRD) Awards ($4M in FY18)

15K+
visitors, since the doors opened in 2009

University Impact at Idaho National Laboratory

111 Students from CAES universities interned at INL

17 Faculty members from CAES universities were awarded joint appointments at INL

14 Students from CAES universities received graduate fellowships at INL

18 Faculty members from CAES universities participated in the CAES Summer Visiting Faculty program.

2 Students from CAES universities were awarded postdoctoral appointments at INL

226 INL employees participated in Employee Education programs at CAES universities

10th Anniversary

CAES celebrates 10th anniversary

Feb. 20, 2019 marked the 10th anniversary of the dedication ceremony for the CAES headquarters in Idaho Falls. The milestone was commemorated with a celebratory event in Boise that drew approximately 100 people, including the Idaho governor and Battelle Executive Vice President of Laboratory Operations Ron Townsend, and featured presentations by INL Director Mark Peters, Former Idaho Gov. C.L. "Butch" Otter, Boise State University President Dr. Marlene Tromp, University of Idaho President C. Scott Green, and former DOE-Idaho official John Kotek, who is now Vice President of Policy Development and Public Affairs at Nuclear Energy Institute.

Change of address – 995 MK Simpson Blvd

In the spring, the city of Idaho Falls renamed the street on which CAES is located in honor of Congressman Mike Simpson and Kathy Simpson. The new name is MK Simpson Boulevard, and CAES' address is now 995 MK Simpson Blvd. In 2009, when the facility was dedicated, CAES was the anchor tenant, the first building with an address along the nearly half-mile stretch of road known as University Boulevard. In the decade since, fields have been replaced by buildings that comprise INL's research campus, "where the hard work of research, education and innovation intersect," as Idaho Falls Mayor Rebecca Casper wrote in a letter to the Simpsons in April 2019, adding, "The CAES facility illustrates this. Bringing together National Lab research with four universities and lots of brilliant students and scientists is a remarkable thing."

RESEARCHER, FACULTY, STAFF, AND STUDENT ACCOMPLISHMENTS


Dr. David Estrada

CAES Associate Director & Boise State faculty member receive NSF CAREER Awards

Dr. David Estrada, the CAES Associate Director for Boise State University, was awarded a National Science Foundation CAREER Award in April for his work utilizing graphene as a bio-scaffold for musculoskeletal tissue engineering, and CAES-affiliated Boise State Assistant Professor Hoda Mehrpouyan was awarded a CAREER Award to further her cybersecurity and network research. Mehrpouyan, who is also Associate Director of the Cyber Lab for Industrial Control Systems at Boise State, received a five-year award of $454,000 to support her work developing a complex security framework providing mechanisms that address the increasing risk of cybersecurity attacks on water treatment plants, reducing the risk to public health and safety, industry, and national security. Mehrpouyan has worked with Idaho Digital Learning, Suez Idaho, Women Innovators of Idaho, and INL, and the CAREER Award will allow her to advance research and expand opportunities for collaboration in cybersecurity, one of the seven focus areas outlined in the CAES Strategy. Estrada, who has served as Boise State Associate Director to CAES since June, was awarded more than $550,000 to support his collaborative research with fellow Boise State Professor Julie Oxford and faculty from the Italian Institute of Technology and Southern Demark University. The research is in the CAES focus area of advanced manufacturing and involves the use of graphene as a bio-scaffold, or engineering structure on which tissue may grow, for stem cell cultures. The work could revolutionize tissue engineering by enabling patient-specific organ growth, which would reduce patients' dependence on donors to treat organ failure. Estrada's five-year CAREER award also includes research activities to help develop a pathway for English language learners from a Boise-based language immersion program to participate in STEM programs at Boise State.

CAES AD for Boise State recognized with national award

In September, Estrada, was recognized by the Council for Opportunity in Education as one of six 2019 National TRIO Achievers. The name of the honor stems from the federal TRIO college access and support programs designed to help low-income, first-generation students and students with disabilities succeed in college. Estrada's parents immigrated from Mexico to Idaho in the early 1960s; neither had finished high school. Estrada and his five siblings all graduated from high school, and he was awarded a scholarship at University of Michigan through the Navy ROTC program. After struggling academically as a freshman, Estrada served six years in the Navy before returning to Idaho to pursue a degree in electrical engineering at Boise State. In 2007, Estrada became the first person in his family to earn a college degree, and he credits the McNair Scholars Program with providing the support and preparation he needed to succeed.

CAES hosts Hiring our Heroes Fellow

CAES hosted Paul Smith as a fellow in the Hiring Our Heroes Fellowship Program throughout fall 2019. Smith contributed to a number of communications projects for CAES, in addition to networking and sharing the story of the fellowship program, which provides military service members with professional training and hands-on experience as they transition from the military to the civilian workforce. A profile on Smith, an Idaho native who served more than 22 years in the US Army, ran on the INL web site and Boise State University web site.

Paul Smith


Dr. Dakota Roberson

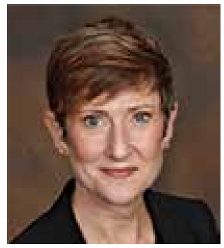
CAESer lands White House Fellowship

CAES resident Dr. Dakota Roberson began serving in the 2019-2020 Class of White House Fellows over the summer. Roberson, an Assistant Professor of Electrical and Computer Engineering at University of Idaho, has been placed at the Department of Defense for the yearlong fellowship. At CAES, he leads an interdisciplinary research team studying electrical grid stability and security, and he is an appointed Nuclear Engineering Affiliate Faculty at University of Idaho. In addition to his professorial duties, Roberson promotes science, technology, engineering, and mathematics education through secondary school outreach and public speaking engagements; he also volunteers at a tech start up and serves as an unpaid advisor on regional energy infrastructure programs, according to a White House news release. Roberson was in the first cohort of the CAES Summer Visiting Faculty Program, in 2018, and he was integral to launching CAES' monthly Codebreaker seminar series, which provides a forum for students and researchers to address their work, communicate opportunities and challenges to a receptive audience, and increase dialogue among CAES affiliates leading to further interdisciplinary collaborations and ground-breaking new research.

A native of Shelley, Idaho, Roberson has collaborated with researchers, scientists, and engineers at several national laboratories, electric utilities, private stakeholders, and universities to mitigate 21st century energy-system threats. His engineering courses at UI are geared toward preparing students for careers in this area.

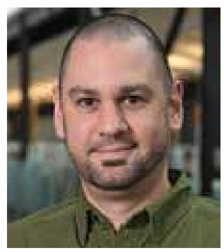
"Dakota is a valuable member of the CAES team and community," said CAES Director Noël Bakhtian, who encouraged Roberson to apply for the fellowship.

The White House Fellows Program was created in 1964 by President Lyndon B. Johnson. The non-partisan program provides professionals from diverse backgrounds an opportunity to engage in public service for one year by serving in various roles in the federal government. Fellows participate in education programs that expand their knowledge of leadership, policy-making and contemporary issues. Community service plays a prominent role in the program as fellows take part in numerous service projects throughout the year. The selection of the fellows is based on a record of professional accomplishment, evidence of leadership skills, the potential for further growth, and a commitment to service.


Dr. Mary Lou Dunzik-Gougar

CAES faculty member sworn in as American Nuclear Society VP at society's national meeting

Dr. Mary Lou Dunzik-Gougar, a CAES faculty member from Idaho State University, was named Vice President of the American Nuclear Society at its annual meeting in June, and is set to take over as the society's president in 2020, making her the first CAESer to serve as president in ANS history (we think!). In addition to serving as the ISU lead for the CAES joint certificate in nuclear security and co-lead of the CAES Nuclear Energy Working Group, Dunzik-Gougar is Associate Dean of the College of Science and Engineering, an Associate Professor of Nuclear Engineering, and Senior Reactor Operator at ISU.


Dr. R.A. Borrelli

University of Idaho ANS Student Section recognized at annual meeting

The CAES-affiliated University of Idaho American Nuclear Society (ANS) Student Section was awarded second place for the 2019 Samuel Glasstone Award at the ANS Annual Meeting in June. Established in 1969, the annual Glasstone Award recognizes ANS student sections that have made notable achievements in public service and the advancement of nuclear science and engineering. The UI ANS Student Section is comprised of about 20 students, combined, on the Idaho Falls and Moscow campuses. Professor R.A. Borrelli, a CAES/UI faculty member, is the section's faculty advisor; CAES/UI graduate student Robin Roper is the current president; and James Richard, also a CAES/UI graduate student, was president last year.

CAES Collaboration Fund winners announced

Recipients of the 2019 CAES Collaboration Fund were announced over the summer. The fund is designed to advance selected proposals by INL researchers that would enhance collaborative relationships with CAES universities, in line with the CAES strategic plan. Here is a look at the recipients, their CAES-affiliated collaborators, and their proposals:

- INL's Brittany Hodges, from the Energy and Environment Science and Technology Directorate, and University of Wyoming faculty members Dean M. Roddick and Katie Li-Oakey, collaborated on a proposal that encompasses two CAES focus areas, Energy-Water Nexus and Innovative Energy Systems, and calls for a visit to the University of

Wyoming, presentation of a seminar, and meetings with potential partners to advance solutions in the two focus areas.

- INL researchers Mary Case and Robert Fox, with the Energy and Environment Science and Technology Directorate, Idaho State University Professor Rene Rodriguez, and Boise State University Professor Kris Campbell developed a proposal that calls for collaboration among the recipients and a possible industry partner to advance solutions in the Advanced Manufacturing focus area, leading to a report on potential collaboration and approaches, a summary of literature searches performed by students, and a summary of discussions at a series of meetings.
- INL's Josh Peterson-Droogh, in the Nuclear Science and Technology Directorate, and ISU Associate Professor Leslie Kerby developed a proposal in the Cybersecurity focus area that calls for developing material to teach advanced machine learning applications for nuclear energy, and hosting several working meetings to hone the material and determine the potential for collaboration in the cross-cutting effort of utilizing data science with nuclear energy.
- INL's Bin Li, with the Energy and Environment Science and Technology Directorate, and BSU Associate Professor Claire Xiong developed a proposal in the Advanced Manufacturing focus area that calls for student mentoring and the development of new concepts or proposals in the field of stationary energy storage.
- INL's Kevin Gering, with the Energy and Environment Science and Technology Directorate, and BSU collaborators Claire Xiong, Eric Jankowski, Will Hughes, and Amy Moll developed a proposal in the Cybersecurity focus area that calls for developing a roadmap of proposal opportunities and possible connections with INL's Collaborative Computing Center and industrial engagement.


Dr. Mustafa Mashal

Idaho State University faculty member named Engineer of the Year

CAES-affiliated Idaho State University Assistant Professor Dr. Mustafa Mashal was named the Southern Idaho Section Engineer of the Year by the American Society of Civil Engineers in March. Mashal participated in the CAES Summer Visiting Faculty program this year, collaborating with INL's Matthew Watrous on a project that addressed two CAES focus areas: Innovative Energy Systems and Cybersecurity. Mashal also received a $1.1 million award from the state of Idaho's Idaho Global Entrepreneurial Mission (IGEM) initiative this year. More information on the IGEM grant is among the Research Highlights included in this report.

CAES researcher lauded

John Peterson, a University of Idaho graduate student who is conducting research at CAES, was recently awarded first place in the Department of Energy-sponsored Innovations in Nuclear Technology R&D Awards. Peterson's award in the program's Energy Policy category was for his research paper "An Overview of Methodologies for Cybersecurity Vulnerability Assessments Conducted in Nuclear Power Plants." The paper was published in the journal Nuclear Engineering and Design in May. The Innovations in Nuclear Technology R&D Awards program is designed to: award graduate and undergraduate students for innovative research publications relevant to nuclear technology, demonstrate the DOE's commitment to higher education in nuclear energy-relevant disciplines, and support communication among university students and DOE representatives.

CAES director selected for STEP board

CAES Director Noël Bakhtian was selected by the National Academies of Sciences, Engineering, and Medicine to serve on its 11-member Board on Science, Technology, and Economic Policy (STEP). She joins 10 other members, selected from industry, academia, and government. The mandate of the STEP board is to advise federal, state, and local governments and inform the public about economic and related public policies to promote the creation, diffusion, and application of new scientific and technical knowledge to enhance the productivity and competitiveness of the U.S. economy and foster economic prosperity for all Americans. The board and its committees draw from the expertise of scholars, industrial managers, investors, and former public officials to help craft policies intended to guide and accelerate scientific and technological change. Members include Board Chair Adam B. Jaffe, Research Professor at Brandeis University; former US Senator Jeff Bingaman (D-New Mexico); Brenda Dietrich, Geoffrion Family Professor of Practice of Operations Research and Information Engineering at Cornell University; Arati Prabhakar, former Director of the Defense Advanced Research Projects Agency; Kathryn Shaw, Ernest C. Arbuckle Professor of Economics at Stanford University; and Scott Stern, David Sarnoff Professor of Management of Technology and Professor of Technological Innovation, Entrepreneurship, and Strategic Management at MIT Sloan School of Management.

CAES reaches milestone of 15,000 visitors

Among the visitors this year:

LISA BERTHELOT
Stakeholder Involvement Officer at International Atomic Energy Agency

DWAYNE BOLTON
DOE Office of Congressional and Intergovernmental Affairs

MIKE CRAPO
US Senator

THOMAS DAVIS
with Oxford University

RUSS FULCHER
US Representative

C. SCOTT GREEN
University of Idaho President

DR. CHRISTIAN KÄHLER
Professor at Universitat der Bundeswehr Munchen

JANICE MCGEACHIN
Idaho Lieutenant Governor

DR. KEVIN NILSEN
senior software engineer at IBM

LARA PEIRPOINT
Technology Strategy Director at Exelon

DR. ARATI PRABHAKAR
former DARPA director

DR. MARLENE TROMP
Boise State University President

MARK YALE
from Department of Energy's Office of Nuclear Energy

A DELEGATION FROM TOKAI-MURA, JAPAN, and IDAHO FALLS' SISTER CITIES PROGRAM

Dozens of HIGH SCHOOL STUDENTS *from across the region*

Members of the IDAHO PERMANENT BUILDING FUND ADVISORY COUNCIL

SENIOR STAFF
from the Naval Nuclear Laboratory

CAES initiates CAES Excellence Certificate award

Throughout the year, students, researchers, and faculty from the CAES entities can nominate their colleagues for their work promoting collaboration, safety, and technical excellence in research, education, and innovation (the CAES strategic pillars). In May, we started drawing a name from the list of nominees each month, with the winner receiving a preferred parking spot for the month. Here's a list of the winners:

May:
Yaqiao Wu, Safety

June:
Kim Jeffery, Collaboration

July:
Kelly Cunningham, Safety

August:
Jana Pfeiffer, Safety

September:
Matt Evans, Collaboration

Research Highlights

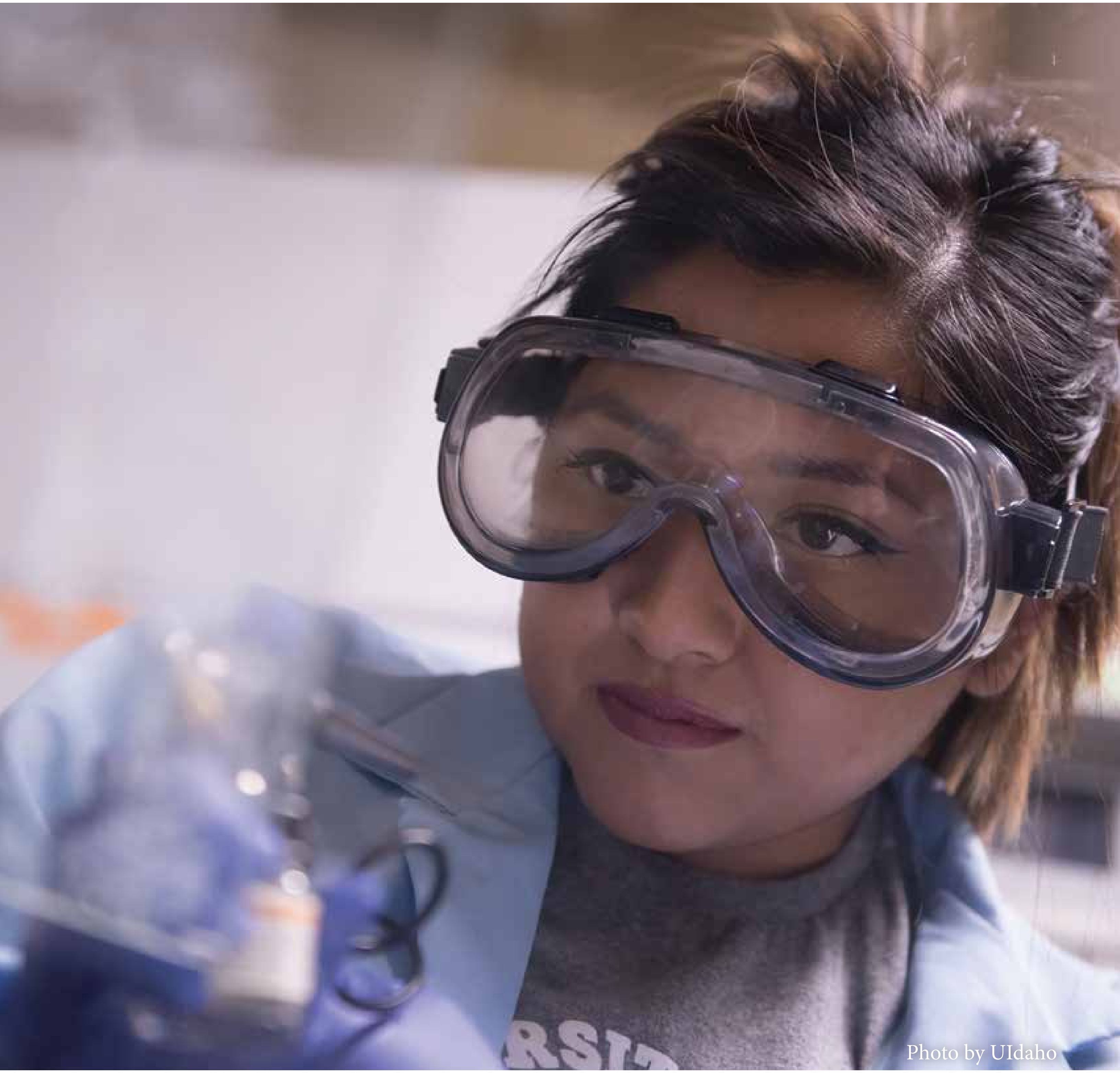


Photo by UIdaho

NuScale simulator bound for CAES

The Department of Energy awarded a grant to CAES-affiliated University of Idaho Professor Richard Christensen to support the installation of a NuScale reactor plant simulator at CAES. The simulator is a virtual nuclear power plant control room that will enhance CAES' ability to inspire, train, and educate the future energy workforce, expand opportunities for collaborative research, and provide a valuable tool for educating the public about nuclear energy and reactor technology. Christensen is the Principal Investigator of the project, *Multi Universities Small Modular Reactor Simulators: NuScale*, which received a Research and Development award from the DOE's Nuclear Energy University Program (NEUP) that is estimated at $285,763. The project calls for collaboration with fellow UI professors Robert Borrelli, Michael Haney, and Michael McKellar, and NuScale's Derrick Both. NuScale is developing a small modular reactor that is under certification review by the Nuclear Regulatory Commission. The reactors are expected to be operational by the mid-2020s as the Carbon Free Power Project, which calls for a small modular reactor power (SMR) plant consisting of 12, 60-megawatt modules located on INL's 890-square-mile desert site. Most of the power generated will go to Utah Associated Municipal Power Systems, which consists of 46 public power utilities in six western states. INL has been involved with NuScale's SMRs for years, assisting with several technical aspects of the project, including modeling and simulation of small modular reactor components and systems. The NuScale project will help INL and DOE research and demonstrate safe, secure, and resilient microgrid systems, and will be part of DOE's INL-led Gateway for Accelerated Innovation in Nuclear (GAIN) program, which makes DOE national laboratory assets available to assist industry in bringing nuclear energy technology to market.

CAESers lead, collaborate on projects recognized by NEUP

CAES-affiliated Professor Mary Lou Dunzik-Gougar from Idaho State University is the Principal Investigator on a project that received a Research and Development award from the Department of Energy's Nuclear Energy University Program (NEUP), while Haiyan Zhao, CAES-affiliated Professor at University of Idaho, is a collaborator on a project that received a NEUP Reactor Concepts Research and Development and Demonstration award.

Dunzik-Gougar's project, *Measuring Mechanical Properties of Select Layers and Layer Interfaces of TRISO Particles via Micromachining and In-Microscope Tensile Testing*, calls for the development of improved modeling of fuel behavior, which would positively impact ongoing efforts in DOE's Advanced Gas Reactor Program to qualify and license TRI-structural ISOtropic (TRISO-coated) particle fuel. Collaborators include Isabella van Rooyen from INL's Nuclear Science & Technology Directorate. NEUP funding for the project is estimated at $799,815.

Zhao is a collaborator on *Ni-based ODS alloys for Molten Salt Reactors*, which will examine the concept of developing new nickel alloy material for molten salt reactors. The project's goal is to resolve problems related to corrosion and irradiation damage that limit the currently available nickel alloys for use in molten salt reactors, while improving the mechanical properties of the material. The project's estimated funding is $800,000. The Principal Investigator is Djamel Kaoumi from North Carolina State University, and Zhao's fellow collaborators are Peter Hosemann of the University of California, Berkeley; David Armstrong and Michael Moody from Oxford University; and INL's Michael V. Glazoff, who is in the INL's Energy and Environment Science and Technology Directorate. The corrosion testing work may be performed by Zhao's research group in the Radiochemistry Laboratory at CAES.

CAES faculty member leads project that receives IGEM grant

Idaho State University's Civil and Environmental Engineering department is leading a CAES-initiated project at the forefront of earthquake and structural engineering research

Dr. Mustafa Mashal and Dr. Bruce Savage

that will enhance collaboration between INL and ISU. ISU was awarded nearly $1.1 million this year from the Idaho State Board of Education's Idaho Global Entrepreneurial Mission (IGEM) initiative to build the Disaster Response Complex (DRC) in Pocatello. The concept and collaboration for the DRC resulted from a 2018 CAES-coordinated collaborative research planning meeting with INL's National & Homeland Security Directorate. CAES-affiliated ISU Professor Dr. Mustafa Mashal is the Principal Investigator on the project, which calls for the construction of a facility that will replicate the features of a structure collapsed by an earthquake, hurricane, or other natural disaster. Mashal and his Co-PI, Dr. Bruce Savage, an associate professor and Chair of ISU's Department of Civil and Environmental Engineering, teamed on the project with INL's Bryon Marsh, establishing a partnership that provides expertise in chemical, biological, radiological, and nuclear (CBRN) research. The DRC will be the first of its kind in the Intermountain West, serving as a training site for first responders to learn search-and-rescue operations in disaster scenarios, enabling research into new disaster response techniques and technology, and supporting future collaborative training and exercises planned for INL's Radiological Response Training Range. Potential clients include Idaho National Guard and the Office of Emergency Management. Seed funding for the project came via a 2018 CAES program development award and a 2018 CAES Collaboration Fund award.

University of Idaho awarded IGEM grant

University of Idaho Professor Indrajit Charit is the Principal Investigator on a collaborative project involving INL and CAES-affiliated Boise State University Assistant Professor Brian Jaques that received a $247,167 grant from the Idaho Global Entrepreneurial Mission (IGEM) initiative. The project calls for using laser beams to manufacture complex and unique metallic parts, with potential applications in nuclear reactors and food processing plants. Jaques is one of five Co-PIs on the project, which also involves Blackfoot-based Premier Technology Inc. INL will serve in an advisory role, and the researchers plan to conduct characterization work at CAES. The project could enable Premier Technology to quickly manufacture complex and unique machine parts on-site – parts such as smart filters for food processing equipment – potentially reducing down-time for equipment and personnel. Another potential application is for US Navy fleets – crews would be able to rapidly manufacture needed materials at sea, without returning to port.

Did you know: The IGEM grant program initiative began in 2012, with the goal of boosting Idaho's economic growth through commercialized research at the state's three public research universities.

CAESers on teams that receive VTR funding

Several CAES-affiliated faculty members at Idaho State University and University of Idaho are members of teams that received funding through the Versatile Test Reactor Program, which DOE created in 2018 to support the development of new nuclear energy technologies in the U.S. The program is led by INL and is charged with developing a conceptual design and cost estimate for a proposed, one-of-a-kind research reactor capable of producing neutrons at higher speeds to support new nuclear technology development.

Richard Christensen and David Arcilesi from CAES/University of Idaho are co-PIs on a team led by the University of Michigan that received $375,000 in funding for its Versatile Test Reactor (VTR) project, Development of a Multi-functional Experimental Vehicle for GFR Irradiation Testing in VTR, in June. Christensen serves as director of UI's Nuclear Engineering program at CAES, and Arcilesi is an Assistant Professor in UI's College of Engineering in Idaho Falls who participated in the CAES Summer Visiting Faculty program in 2018.

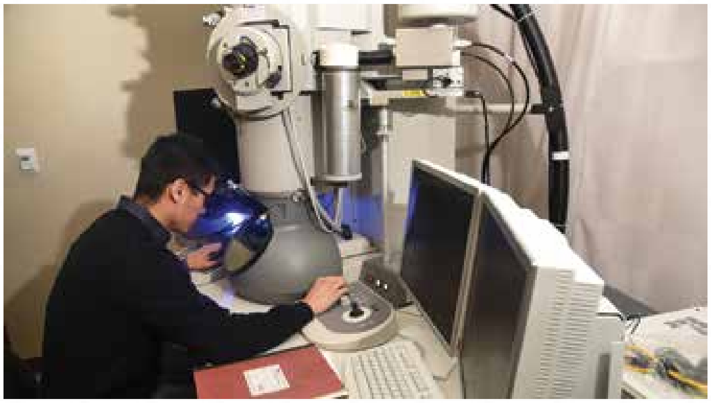
ISU Professors Goerge Imel and Chad Pope also serve as co-PIs on teams that were recognized in June. Imel, a CAES-based Nuclear Engineering professor at ISU, is a co-PI on a project led by Purdue University called In-Situ Irradiation Creep Testing Vehicle Instrumented with Novel Sensors that was awarded $350,400. Pope, director of ISU's Nuclear Engineering program who has taken part in several successful projects at CAES, including a 2015 project that received a $200,000 grant from INL to study the performance of nuclear power plant components under flooding conditions, serves as co-PI on an Oregon State University-led project, Accelerating the Experimental Mission of VTR Through an Ex-Pile Operational Program, that received $250,000 in funding through the VTR program.

In all, the VTR program awarded $1.7 million in funding to six university-led projects in June. The funding is intended to allow the universities to develop instrumentation and tools for a proposed research reactor that would generate high-speed – or "fast" – neutrons for experimentation and testing purposes.

While INL leads the VTR program, its team consists of Argonne National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, Savannah River National Laboratory, and industry and university partners.

2019 Laboratory Directed Research and Development Awards (LDRD)

Award	Recipient	Research/Development
$786,434	Colby Jensen (INL), Richard Christensen (UI), Alberto Cardenas Melgar (UI)	In-Pile Investigation of Transient Boiling in TREAT
$518,140	Bjorn Vaagensmith (INL), Curtis Cantley (BSU)	Robust Insulation for Resilient Transformers Against a Electromagnetic Pulse or Geomagnetic Disturbance
$485,511	Eric Dufek (INL) Lan Li (BSU), Caire Xiong (BSU), Haoyu Zhu (BSU)	Carbon: Interfaces, Structure and the Impacts on Performance
$475,000	Danuel Schwen (INL)	Mitigating Irradiation Assisted Stress Corrosion Cracking by Rapid Alloy Design
$430,000	Adrian Wagner (INL), Brian Jaques (BSU)	Advanced Manufacturing of Uranium Dioxide Fuel Pellets with Radially and Axially Zones Burnable Poisons and Hour-glassing Control Features
$384,750	Junhua Jiang (INL), Haiyan Zhao (UI)	Three-Dimensional Electrochemical Manufacturing and Sensing (3DEMS)
$377,300	David Hurley (INL), Christy Allison (BSU), Jon Huff (BSU), William Kowlton (BSU), Ryan Pensack (BSU), Paul Simmonds (BSU), Kevin Daniel Vallejo (BSU), Bernard Yurke (BSU)	Investigation of Exciton Delocalization and Exciton Coherence in Chromophores and Acoustic Nanostructures
$282,500	Ronald Boring (INL), Harold Blackman (BSU)	Human Reliability Analysis for Advance Reactor Technologies and Systems
$275,000	Craig Rieger (INL), Michael Haney (UI), Brian Johnson (UI), Philip Richardson (UI)	Resilient, Scalable Cyber State Awareness of Industrial Control System Networks to Threat
$266,860	Edna Cardenas (INL), Jon Stoner (ISU)	Novel Methods to Produce an Argon-37 Standard
$251,396	Kevin Gering (INL), Bryton Anderson (BSU), Mike Henry (BSU), Eric Jankowski (BSU), Matthew Jones (BSU)	Surface Morphological Patterning, Structure-activity Modeling, and Aging Analysis of Catalyst Materials to Enhance Oxidative Dehydrogenation of Ethane Reaction Coversion Efficiency
$208,846	Cheng Sun (INL), Ryan Carnahan (ISU)	Advanced Manufacturing of Fuel Cladding Materials by Equal-channel Angular Pressing
$205,333	Kevin Lyon (INL), Jarod Perko (UI), Vivek Utgikar (UI)	Modeling and Simulation for Nuclear Fuel Cycle Separations Using Modular Coupling
$96,000	Gary Groenewold (INL), Yaqiao Wu (BSU)	Separation of Fragile Chemical; Species Using Carbon Nanotube Emitters at Very Low Electrical Potential



NEUP Nuclear Energy University Program
U.S. Department of Energy

2019 Nuclear Energy University Program Awards (NEUP)

Award	Recipient	Research/Development
$285,763	NEUP Infrastructure (Prime award) Rich Christensen (UI)	NuScale Simulator
$799,815	NEUP CINR (Prime award) Mary Lou Dunzik-Gougar (ISU), Isabella van Rooyen (INL)	Measuring Mechanical Properties of Select Layers and Layer Interfaces of TRISO Particles via Micromachining and In-microscope Tensile Testing
$800,000	NEUP CINR (Partner award) Djamel Kaoumi (NC State), Haiyan Zhao (UI), Michael Moody and David Armstrong (Oxford), Peter Hosemann (UC-Berkeley), Michael Glazoff (INL)	Ni-based ODS Allows for Molten Salt Reactors
$499,997	NEUP CINR (Partner award) Zhao Ji-Cheng (Ohio State), Yaqiao Wu (BSU), Ed Lahoda (Westinghouse)	Neutron Radiation Effect on Diffusion Between Zr (and Zircaloy) and Cr for Accurate Lifetime Prediction of ATF

Team with CAES connections receives NSF award

CAES Associate Director for University of Wyoming Katie Li-Oakey is a Co-PI on a project that received a National Science Foundation (NSF) Major Research Instrumentation award. The proposal, which is led by University of Colorado Assistant Professor Adam Holewinski and INL's Rebecca Fushimi, is called *NSF MRI: Acquisition of a High-Sensitivity Low-Energy Ion Scattering (HS-LEIS) Spectrometer with Multiple Reactive Environment Transfer for Interrogating Surfaces and Interfaces*. The project has been awarded more than $880,000 for a HS-LIES spectrometer that will be publicly available and will enable collaboration in studying catalysis, atomic layer deposition and coatings, photovoltaics, and solid state structure and interfaces, among other areas. The spectrometer will be the second comparable instrument in North America today.

Dr. Katie Li-Oakey

CAESer receives DOE award for geothermal project

The DOE's Geothermal Technologies Office awarded funding to an INL-CAES geothermal energy storage project focused on determining whether reservoirs deep within the earth could be used to store energy. The collaborative project, *Dynamic Earth Energy Storage: Terawatt-Year, Grid-Scale Energy Storage using Planet Earth as a Thermal Battery*, is led by Principal Investigator Travis McLing of INL/CAES and includes researchers from University of Idaho, University of Wyoming, Rocky Mountain Power, and Lawrence Berkeley National Laboratory. It was one of eight projects selected to receive up to $2.4 million in funding via the Beyond Batteries Lab Call: Geothermal Energy Applications for Storage Alternatives and support the objectives of the DOE Grid Modernization Initiative. The projects are exploring opportunities for integrating geothermal energy into various functions in support of the Beyond Batteries objectives. These include dispatchability, co-production, and hybrid operations to improve grid reliability, resilience, and security.

CAES Collaboration Fund recipient gets published

Ahmad Al Rashdan, a Senior Research and Development Scientist in INL's Nuclear Science and Technology Directorate, wrote a research paper published in *IEEE Transactions on Nuclear Science*. The project behind the paper, *A Frequency Domain Control Perspective on Xenon Resistance for Load Following of Thermal Nuclear Reactors*, was funded through the CAES Collaboration Fund, a program designed to provide funding to selected proposals by INL researchers that would enhance collaborative relationships with CAES universities, in line with the CAES strategic plan. Rashdan teamed with CAES-affiliated University of Idaho Assistant Professor Dakota Roberson on the project.

Working groups assembled to implement strategic plan

Researcher-led working groups have been developed in each of the CAES focus areas, with recruitment underway at the end of the fiscal year. The goal is to help implement the CAES strategic plan, with the groups serving as catalysts for a community of researchers in each of the strategic focus areas, leading to new collaborations, external funding, and maximum impact in research, education, and innovation. The working groups will have access to funds to accelerate these outcomes. There are seven groups focusing on Nuclear Energy; Energy-Water Nexus; Cybersecurity; Advanced Manufacturing; Innovative Energy Systems; Energy Policy; and Computing, Data, and Visualization.

Working Group	Working Group Leads
Nuclear Energy	Rich Christensen, UI; Mary Lou Dunzik-Gougar, ISU; Don Wood, INL
Energy-Water Nexus	Jon Brant, UW; Karen Humes, UI
Cybersecurity	Jim Alves-Foss, UI; Wayne Austad, INL; Corey Schou, ISU
Advanced Manufacturing	David Estrada, BSU; Rob O'Brien, INL
Innovative Energy Systems	John Gardner, BSU; Scott Quillinan, UW
Energy Policy	Kathleen Araujo, BSU; Kipp Coddington, UW
Computing, Data, and Visualization	Leslie Kerby, ISU; John Koudelka, INL

Education Highlights

Photo by UIdaho

CAES Summer Visiting Faculty program

The CAES Summer Visiting Faculty program completed its first full year in 2019 with 18 participants, each partnered with an INL researcher. The program fosters collaboration among INL researchers and university professors in order to develop a joint-funded research proposal. The ultimate goal is to build a sustainable ecosystem of research collaboration as is outlined in the CAES strategic plan. The program ran from June 3 to August 8, giving participants a glimpse at the inner workings of a national laboratory (including opportunities at the new Cybercore Integration Center and Collaborative Computing Center [C3]) while allowing them to learn about the capabilities and expertise afforded by collaboration with researchers at a national laboratory. It also provides the faculty and INL researcher an opportunity to create lasting networks and gain access to diversified funding options. This year, proposals were solicited from faculty in all seven focus areas outlined in the CAES Strategy.

Here's a list of the participants in the 2019 CAES Summer Visiting Faculty Program:

University Faculty	Institution	INL Researcher	Focus Area(s)
Liljana Babinkostova	BSU	Robert Erbes	Cybersecurity
Zhangxian (Dan) Deng	BSU	Michael Shaltry	Advanced manufacturing
David Estrada	BSU	Rebecca Fushimi	Energy-water nexus
Tony Forest	ISU	Daniel Schwen	Nuclear energy; computing, data, and visualization
Michael Hurley	BSU	Donna Guillen	Advanced manufacturing
Brian Jaques	BSU	Subhashish Meher	Nuclear energy
Nirmala Kandadai	BSU	Joshua Daw	Energy-water nexus
Leslie Kerby	ISU	Leah Guzowski	Computing, data, and visualization
Constantinos Kolias	UI	Craig Rieger	Cybersecurity
Michal Kopera	BSU	Cody Permann	Computing, data, and visualization
Min Long	BSU	Larry Aagesen	Advanced manufacturing; computing, data, and visualization
Mustafa Mashal	ISU	Matthew Watrous	Innovative energy systems; cybersecurity
Mike McKellar	UI	Donna Guillen	Nuclear energy; advanced manufacturing; innovative energy sysems
Thomas Ptak	UI	Noël Bakhtian	Energy policy
Zouheir Rezki	UI	Arup Bhuyan	Cybersecurity
Edoardo Serra	BSU	Shane Stailey	Cybersecurity; computing, data, and visualization
Min Zian	UI	Su-Jong Yoon	Computing, data, and visualization
Yaqi You	ISU	Chenlin Li	Nuclear energy; energy-water nexus; cybersecurity

5 students from CAES-affiliated universities among 12 selected for INL Graduate Fellows program

Three graduate students from the University of Idaho and two from Boise State University were among the 12 students selected into the third cohort of INL graduate fellowship program from universities throughout the US. The program is a collaboration between INL and the universities that is designed to identify exceptional talent in research areas aligned with INL's strategic agenda. Fellows receive mentoring from a technical advisor at INL and the university thesis advisor, as well as nationally competitive financial support – tuition and a stipend – throughout the program. The goal is to train the next generation of engineers, researchers, scientists, and leaders in order to enable the current and future mission of INL and DOE.

Graduate Fellow	University	Major	INL Mentor	INL Directorate
Robert Ivans	Boise State University	Electrical and Computer Engineering	Craig Rieger	National and Homeland Security
Tyler Phillips	Boise State University	Computing-Computer Science	Craig Rieger	National and Homeland Security
James Richards	University of Idaho	Nuclear Engineering	Cristian Rabiti	Nuclear Science and Technology
Amey Shigrekar	University of Idaho	Nuclear Engineering	Richard Boardman	Nuclear Science and Technology
Kevin Terrill	University of Idaho	Mechanical Engineering	Colby Jensen	Nuclear Science and Technology

Idaho universities collaborate on fellowship program

Idaho's three public research universities are collaborating on a yearlong fellowship aimed at providing the state's scientists and engineers the opportunity to learn firsthand about policymaking.

The Idaho Science and Technology Policy Fellowship (ISTPF) is a nonpartisan professional development program led by the James A. and Louise McClure Center for Public Policy Research at University of Idaho. The first cohort is set to begin in August 2020. The intent is to connect doctoral-level scientists and engineers to the development of relevant state policies, with a focus on challenges such as water, energy, public health, and economic development and provide technical expertise to Idaho policy makers. Initial funding for the ISTPF is from the California Council on Science and Technology in partnership with the Gordon and Betty Moore Foundation and the Simons Foundation. CAES Director Noël Bakhtian serves as chair of the ISTPF advisory board. Other advisory board members include CAES EPI Director Kathleen Araújo, and representatives from the Micron Foundation, Idaho Technology Council, Idaho STEM Action Center, St. Luke's Health System, and several Idaho state agencies, among others.

Boise State-Idaho State Wind Tunnel Transfer

Two CAES entities, Boise State University and Idaho State University, collaborated on a project that resulted in ISU receiving what may be the largest wind tunnel in Idaho. The tunnel belonged to the Boise State's Mechanical and Biomedical Engineering Department but had been in storage due to a shortage of space on campus. Dr. Mustafa Mashal, a CAES-affiliated Assistant Professor of Structural and Earthquake Engineering at Idaho State, having heard about the status of the wind tunnel, approached CAES Energy Policy Institute Director Kathleen Araújo about moving the structure to the Idaho State campus, noting that it would be a valuable research tool for his department. It can be used for structural testing of wind turbines and small modular reactors, for example. After negotiations involving department chairs Bruce Savage and Katy D'Amico, the transfer of $100k in equipment was carried out successfully weeks later, a testament to CAES' ability to leverage resources for the gain of its members.

CAES intern pens book chapter

CAES intern Rajiv Khadka, a PhD candidate in Computer Science at University of Wyoming, became a published author in late June. Khadka co-wrote a chapter in VR Developer Gems, a book that serves as a reference guide for computer programmers of all skill levels, novice to expert. Each chapter was written by "veteran virtual reality researchers and developers," and offers tips to help the reader find solutions to programming problems. The title of Khadka's chapter, which he wrote with UW Professor Amy Banic and research colleague Elliot Hunt, is Bi-Manual Interaction for Manipulation, Volume Selection, and Travel: Using the leap Motion, Game Controllers and Mobile Devices. It is based on Khadka's work at CAES' Applied Visualization Laboratory and the 3D Interaction and Agents Research Lab at University of Wyoming.

Rajiv Khadka in CAES' Applied Visualization Laboratory

Innovation Highlights

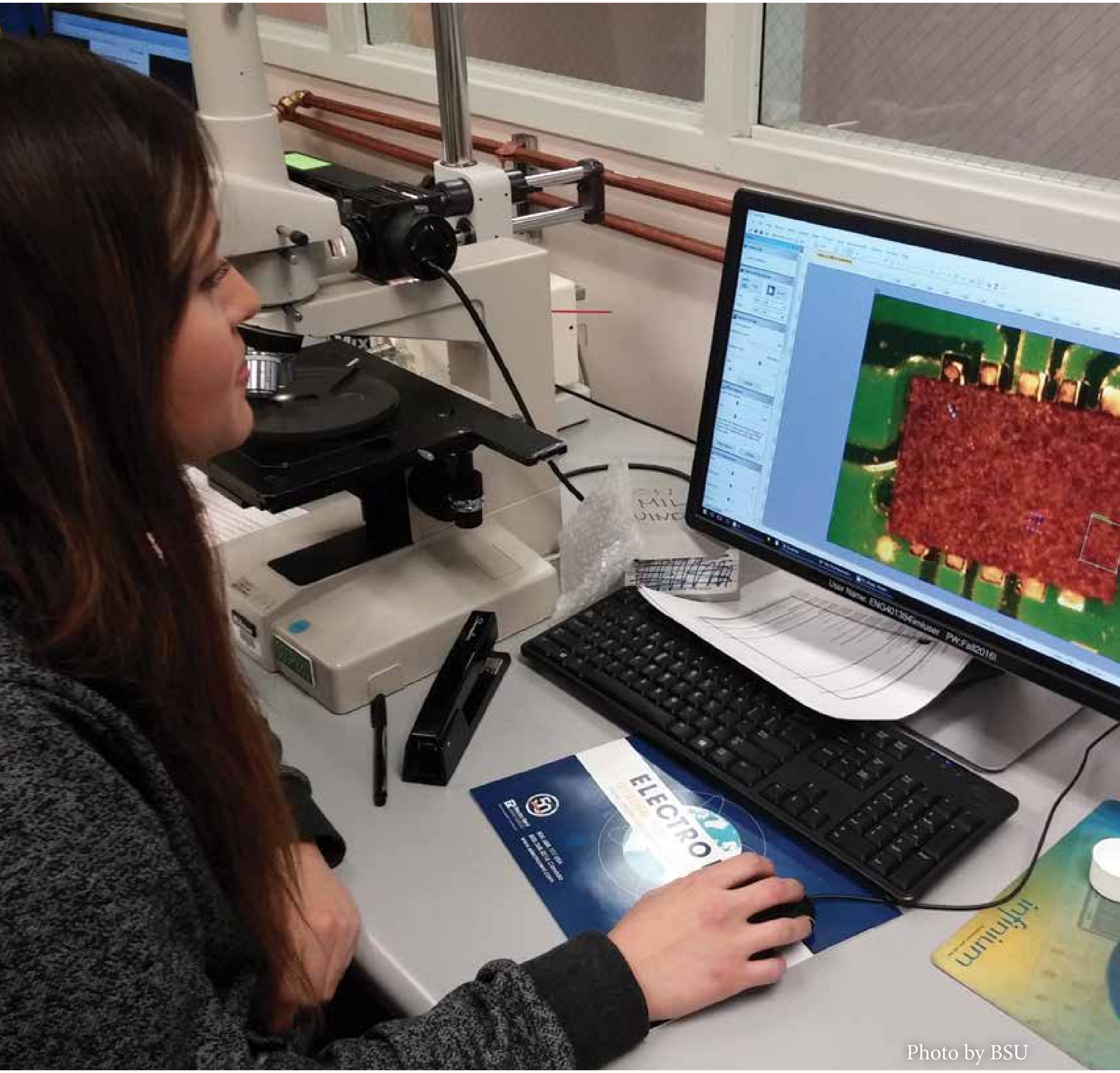
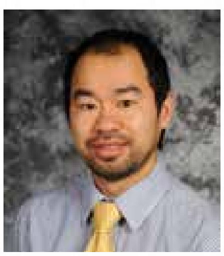


Photo by BSU

CAES hosts CO*STAR training

INL's Technology Deployment group held a CO*STAR training session in the CAES Auditorium in August, with a total of 52 INL researchers and CAES university personnel registering to learn practices proven to help develop new ideas, create winning proposals, and ensure research being conducted at the CAES entities has a tangible, positive impact in alignment with the innovation pillar outlined in the CAES strategic plan. The CO*STAR method imparts best practices for researchers to find opportunities for innovation, come up with creative solutions, communicate in a clear and compelling manner, and create cost-effective prototypes. It also teaches how collaboration can lead to rapid improvement of ideas and provides tips for developing a value proposition. The training aligns with the Innovation pillar outlined in the CAES Strategy, which calls for collaborative innovation that supports entrepreneurial opportunities, industry partnerships, and tech-to-market impact. CAES not only helps pair key regional industries with INL researchers and CAES faculty and students, but also helps them leverage the intellectual property they created – through training such as CO*STAR - to bring research and development to market and, in turn, benefit our communities and businesses.


Roger Lew

Team with CAES connections to participate in Energy I-Corps Cohort 9

An INL team with CAES connections was selected to participate in Energy I-Corps, a DOE/INL program that pairs research teams with industry mentors for intensive training. The training allows researchers to gain insight into industry engagement that will help guide future research and create a culture of market awareness in the Department of Energy's national laboratories. The goal is to ensure the nation's investment in the national labs is maintaining and strengthening long-term US competitiveness. Over the two-month training, researchers define technology value propositions, conduct customer discovery interviews, and develop viable market pathways for their technologies. Team Rotoro, one of two INL teams selected to participate, consists of INL Researchers Ronald Boring and Thomas Ulrich of the Nuclear Science and Technology Directorate, University of Idaho Professor Roger Lew, and industry mentor Eric Harvey. The team developed a nuclear power plant simulator that has been streamlined and simplified to allow rapid demonstration of control room concepts for new reactors. The simulator is touted as being easy to customize, portable, and flexible. It is also capable of facilitating classroom training and can be used in areas where it is not feasible to build a full-scale simulator, such as a university laboratory.

CAESer awarded patent

Dakota Roberson, a CAES-affiliated Assistant Professor at University of Idaho, and John F. O'Brien from University of Wyoming, were awarded US Patent No. 10,355,485 B2 on July 16 for their invention, Variable Loop Gain Using Excessive Regeneration for a Delayed Wide-Area Control System, which could improve the safety and stability of the electric grid. The patent was officially awarded to the University of Wyoming and was made possible by a DOE grant.

INL chemist awarded Technology Commercialization funding for 2 projects with Boise State University


Prabhat Tripathy

INL Chemist Prabhat Tripathy was recognized by Department of Energy's Office of Technology Transitions Technology Commercialization Fund (TCF) for two projects on which he is collaborating with Boise State University and industry partner Inflex Labs, LLC.

Each of the projects, *Advanced Manufacturing of Electrochemical Sensors for Molten Salt Applications* and *Fabrication of Near-net-shape Metallic Components from Oxides*, received $150,000, with half of the funding coming from DOE along with matching funds from Inflex Labs. TCF was created in 2005 to promote projects with the potential to advance promising commercial energy technologies and bolster collaboration between DOE's national labs and industry.

NEW LEADERSHIP

Dr. Marianne Walck (Steering Committee)

Dr. Marianne Walck joined the steering committee in January 2019, when she took over as INL's Deputy Laboratory Director for Science and Technology and Chief Research Officer. Dr. Walck came to INL from Sandia National Laboratories' California laboratory, where she served as Vice President in charge of its Energy and Climate Program and was responsible for principal programs including stewardship or nuclear weapons, homeland security with a focus on defending against weapons of mass destruction, hydrogen energy research, biology, and advanced computational and information systems. Walck serves on several advisory board for universities and technical institutes, including the Texas A&M Energy Institute, and is a Senior Fellow on the California Council on Science and Technology. She earned PhD and Master's degrees in Geophysics from the California Institute of Technology and a Bachelor's degree in Geology/Physics from Hope College.

Dr. Scott Snyder (Steering Committee)

Dr. Scott Snyder was named Interim Vice President of Research at Idaho State University in December 2018. Dr. Snyder also serves as Dean of ISU's College of Science and Engineering. He joined ISU in June 2018 after serving nearly eight years as Chief Research Officer and Associate Vice Chancellor at the University of Nebraska Omha (UNO). In 2013, Dr. Snyder was appointed Interim Executive Director of the Peter Kiewit Institute, a teaching and research institute comprised of UNO's College of Information Science and Technology and the University of Nebraska Lincoln's College of Engineering in Omaha. Snyder initially joined UNO in 2001 as a faculty member in Biology and became a full Professor in 2008. From 2008-2010, he served as Program Director in the Division of Environmental Biology at the National Science Foundation. Snyder has also held a faculty position at the University of Wisconsin Oshkosh and was an NSF/Alfred P. Sloan Postdoctoral Fellow in Molecular Evolution at the University of New Mexico. Snyder earned his PhD in Parasitology at the University of Nebraska-Lincoln, where he also earned his Bachelor's in Biology. He earned his Master's in Parasitology at Wake Forest University.

Dr. David Estrada (Executive Board)

Boise State University Associate Professor Dr. David Estrada was named as CAES Associate Director for BSU in June. Estrada has been a CAES-affiliated faculty member at BSU's Micron School of Materials Science and Engineering since 2013, when he earned his PhD in Electrical Engineering at University of Illinois at Urbana-Champaign. Estrada is the Boise State lead for the Advanced Manufacturing efforts of the DOE's In-Pile Instrumentation Program, and he runs a NASA EPSCoR program to develop technology's for in-space manufacturing of flexible electronics and sensors. Estrada also serves as co-lead of the Advanced Manufacturing Working Group at CAES. A US Navy veteran, Estrada is a past-recipient of NSF and National Defense Science and Engineering Graduate Fellowships. He took over as Associate Director for Dr. Amy Moll.

Dr. Katie Li-Oakey (Executive Board)

Dr. Katie Li-Oakey succeeded Don Roth as CAES Associate Director representing University of Wyoming in July. Li-Oakey received her PhD and postdoctoral training from the University of Colorado. She joined the faculty at UW's Department of Chemical Engineering in 2011, after working at several companies, including Intel Corporation and startups such as Mesoscopic Devices, Metafluidics, and DRC Metrigraphics. Her research focuses on surface and interface chemistry, engineering, and bottom-up nanomaterial design and synthesis such as covalent organic frameworks to address challenges in the areas related to energy, water, and healthcare. In addition to high-impact journal publications, Li-Oakey and her research group developed a patent portfolio upon which she founded TLS Materials, LLC in 2016.

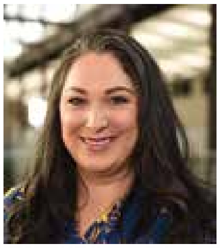
Dr. David Rodgers (Executive Board)

Dr. David Rodgers was named CAES Associate Director for Idaho State University in July. An ISU faculty member since 1985, Rodgers also serves as ISU's Associate Vice-President for Research. He recently returned from sabbatical in Tajikistan, where he spent the 2018-2019 academic year as a Fullbright Scholar at the University of Central Asia. From 2010-2018, Rodgers was Associate Dean in the ISU College of Science & Engineering, and from 2013 to 2018, Rodgers was ISU Site Leader for MILES (Managing Idaho's Landscapes for Ecosystem Services), a research program that involved 100-plus participants at Idaho's three research universities. In that position, he managed more than $4 million in grants from the National Science Foundation. Rodgers earned his PhD in Geology from Stanford University and his Bachelor's from Carleton College. He succeeds Dr. Richard "Jake" Jacobsen.

Dr. John Russell (Executive Board)

Dr. John Russell was named CAES Associate Director for University of Idaho in late 2018. Russell is a recognized expert in chemistry and materials science who also is a joint-faculty appointment with INL. Prior to his arrival at CAES, Russell spent three years in policy advisor roles, most recently as a congressional nuclear security fellow for the office of U.S. Sen. Steve Daines, (R-Mont.). Russell advised Daines' staff on a variety of topics, including quantum information science, advanced computing, 5G wireless, and coal-fired power plants. He was also a Science and Technology Fellow at the American Association for the Advancement of Science, serving as a Cybersecurity Research and Development Policy Advisor for the National Science Foundation and as an Energy and Advanced Computing Research and Development Policy Advisor for Department of Energy. Russell earned his doctoral degree from the University of Illinois at Chicago. He replaced Rich Christensen.

Additional Hires



Amy Woodard

Amy Woodard is Business Operations Specialist for CAES, having replaced Jeff Benson in September. She is responsible for coordination of business outcomes, project management, and CAES process improvement. Prior to joining CAES, Woodard worked for Zions Bank as the Regional Commercial Real Estate Portfolio Manager and Vice President. As Portfolio Manager, she handled the commercial construction and real estate loan portfolio for the region, with individual projects ranging from $1 million to $80 million. Woodard specializes in underwriting, construction contracts, and financial analysis. She holds a Bachelor of Business Administration Degree in Finance from Idaho State University.

Matt Evans

Matt Evans became the CAES Communications Lead in May, replacing Ethan Huffman. He handles marketing materials and branding, social media content, interesting developments and feature stories, press releases, presentations, facility tours, and more. Evans' background is in journalism, having worked for more than a decade as a newspaper reporter and editor. He has been involved in the energy industry since 2010, most recently as Policy Advisor/Public Information Officer for the Idaho Public Utilities Commission. Prior to that, he spent seven years as Communications Lead at Idaho Falls Power.

CAES HOSTED OR PARTNERED ON 68 WORKING MEETINGS, SEMINARS, AND SPEECHES

Here's a glimpse:

My Amazing Future at CAES

CAES hosted nearly 150 eighth-grade young women for the annual My Amazing Future day in February. In its 12th year, the INL event allows students from throughout the region to interact with researchers, engineers, and scientists at INL, giving the young scholars a chance to explore more than a dozen topics including DNA extraction from a strawberry, cybersecurity, radioisotope thermoelectric generators, and hands-on chemistry. The program is designed to show the young women that scientific and technical fields can provide rewarding professional opportunities. A number of CAESers volunteered to help with this effort: CAES Administrator Donna Wuthrich took the lead and was assisted by CAES Director Noël Bakhtian, Leslie Kerby from Idaho State University, INL's Thomas Szewczyk, and Meng Shi and Haiyan Zhao from University of Idaho.

CAES hosts 2019 Center for Space Nuclear Research Fellowship

The Center for Space Nuclear Research Fellowship program kicked off at CAES in June with 16 students from across the country, including two from CAES universities – Spencer Charles Ercanbrack from Idaho State University and Joseph Hafen from University of Idaho. In its 14th year and led by

Dr. Stephen Herring, the program follows the CAES model of fostering collaboration among the students and INL scientists as they team up to complete research projects of interest to NASA. This year's program focused on three projects, one involving the optimal configuration of INL's Advanced Test Reactor for the production of Pu-238 to provide power and heat for spacecraft bound for the outer solar system and beyond, modeling the impact of changes in the oxygen content of heat sources uses in space missions, and studying potential new heat sources for missions to the moon and Mars. The students were divided into teams based on the fields of expertise needed to tackle each project, but the program also provides the fellows an opportunity to explore fields beyond their majors, in order to expose them to cross-disciplinary approaches to challenging, real-world problems.

CAES hosts CINR and LDRD workshops

CAES, in collaboration with the National University Consortium (NUC), hosted a two-day CINR Workshop in August. The event featured more than two dozen breakout sessions timed to coincide with the DOE's Office of Nuclear Energy's (DOE-NE) FY20 Consolidated Innovative Nuclear Research (CINR) funding opportunity announcement. The CINR funding announcement is managed by the Nuclear Energy University Program (NEUP), which aligns DOE-NE's mission with academic nuclear energy research. The workshop served as an opportunity for INL researchers to foster ideas for joint proposals with university researchers within CINR work scope areas. Breakout sessions focused on an array of topics, including Electromechanical Separations; Used Nuclear Fuel Disposition; Thermal Fluid Applications; Big Data, Machine Learning, and Artificial Intelligence; a funding overview; Advanced Methods for Manufacturing; and Multiscale Nuclear Performance. More than 100 researchers attended.

CAES and NUC also teamed up in February to hold a joint workshop focused on partnering for INL's Laboratory Directed Research and Development (LDRD) call. The two-day event featured breakout sessions led by INL subject-matter experts on INL's LDRD topics, including nuclear energy competitiveness and leadership, integrated fuel cycle solutions, advanced integrated energy systems, and advanced design and manufacturing.

CAES hosts Idaho chapter of Women in Nuclear kickoff

Idaho Women in Nuclear, a state-wide professional organization with core initiatives focused on professional development, nuclear energy and technology advocacy, and networking, held its kickoff meeting in the CAES Auditorium in June. Dr. Marsha Bala, Nuclear Energy Innovative Capabilities National Strategic Director at INL, led the public meeting.

CAES hosts data science training meetings

Dr. Leslie Kerby, a CAES-affiliated faculty member at Idaho State University, and Dr. Joshua Peterson-Droogh from INL held a series of data science training sessions throughout the spring and summer that were aligned with the CAES focus area of Computing, Data, and Visualization. Funding for the meetings was made possible through CAES Collaboration Funds. Kerby, an Assistant Professor at ISU, was a member of the team that won the Institute of Electrical and Electronics Engineers (IEEE) Big Data, IEEE Big Brain Hackathon competition at COMPSAC 2018 in Tokyo.

CAES collaborates on cybersecurity seminar

CAES started a series of monthly cybersecurity talks from late summer through the end of the fiscal year. The cybersecurity series is sponsored by CAES and Cybercore, in collaboration with University of Idaho-Idaho Falls and Idaho State University-Idaho Falls, and is intended to further the collaborative objectives outlined in the CAES Strategy while bolstering Cybercore's mission of protecting critical infrastructure systems from an always-evolving threat landscape.

CYBERCORE
integration center

CAES hosts CIOs for IT overhaul

CAES hosted Chief Information Officers of the CAES entities to outline upgrades to the facility's information-technology infrastructure. The collaborative meeting marked the first time the CIOs had met together and was intended to accelerate the development of a plan that will best enable collaborative research and development at CAES.

CAES leads Artificial Intelligence Meeting

About 30 participants, including the Deputy Director of National Center for Atmospheric Research and representatives from INL, attended a CAES Artificial Intelligence meeting held at University of Wyoming in Laramie. Participants established a foundation for collaborations and a way forward to position the group for success in upcoming Funding Opportunity Announcements. Additionally, participants pledged to recruit pipeline companies as industry collaborators with CAES.

Cyber Fallout 5 training co-sponsored by CAES

Twenty participants from the CAES entities took part in a one-week workshop provided by CAES Leadership and the INL Cybercore Integration Center team. Cybercore and CAES collaborated to pilot the program for students, faculty, and professionals from all over the world. Attendees earned academic credit from Idaho State University upon completion of the course, which focused on the key technologies found in a nuclear facility and identified the skills needed to assess cyber risks and vulnerabilities. The original Cyber Fallout course is taught by the INL Cybercore team worldwide through the International Atomic Energy Agency (IAEA) at INL.

SEMINAR SERIES

CAES Director's Colloquium debuts

Dr. Arati Prabhakar

Former DARPA Director Dr. Arati Prabhakar spoke at the inaugural CAES Director's Colloquium in September in the INL Meeting Center. The event was open to the public and drew more than 100 people, including students and faculty who watched a live stream from event spaces at Idaho State University and University of Wyoming. Prabhakar served as Director of the Defense Advanced Research Projects Agency (DARPA) from 2012 until 2017, and as the first female Director of the National Institute of Standards and Technology (NIST) from 1993 to 1997. DARPA is a branch of the US Department of Defense charged with advancing innovative, often revolutionary, military technology for use in the public sector, while NIST promotes US innovation and industrial competitiveness by advancing measurement science, standards, and technology. Prabhakar is currently CEO of Actuate Innovation. Her presentation, *Changing What's Possible: The Power of Breakthrough Technologies*, focused on the potential for innovation to help society overcome challenges associated with the energy-water-food nexus, digital infrastructure, and health outcomes. The annual CAES Director's Colloquium is designed to promote open dialogue between world-class speakers and the public in a community setting that provides insight into research activities, current events, best practices, and career and life journeys.

Codebreaker

The CAES Codebreaker seminar series brought in internal and external talent for general education and collaborative matchmaking to fill the auditorium throughout the year.

Speakers included:

October: Brian Jaques, Boise State University, *Advanced Materials Research for Nuclear Applications*

November: Amy Banic, University of Wyoming, *Importance of 3D UI/UX for Immersive Visualizations and Virtual Reality Applications*

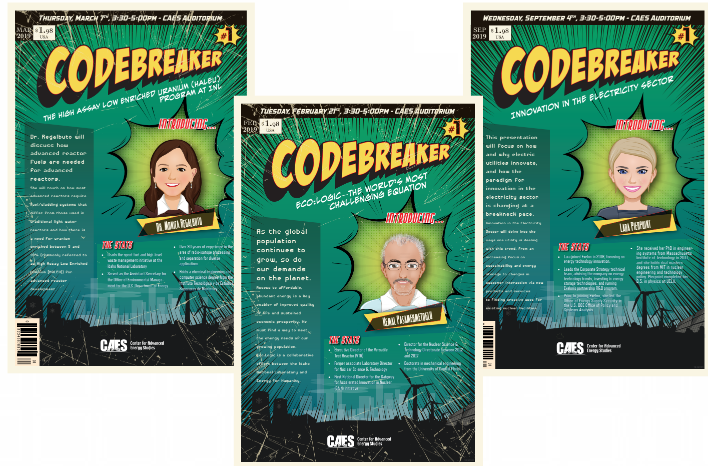
December: Mustafa Mashal, Idaho State University, *The Importance of Structural and Earthquake Engineering*

January: Glen Tait, Idaho National Laboratory, *A View from Washington: Representing INL in the Nation's Capital*

February: Sean McBride, Idaho State University, *Cybersecurity and Critical Infrastructure Protection*

March: Monica Regalbuto, Idaho National Laboratory, *The High Assay Low Enriched Uranium (HALEU) Program at INL*

April: Roger Plothow, Adams Publishing Group, *Science is Not Finished Until It Is Communicated*



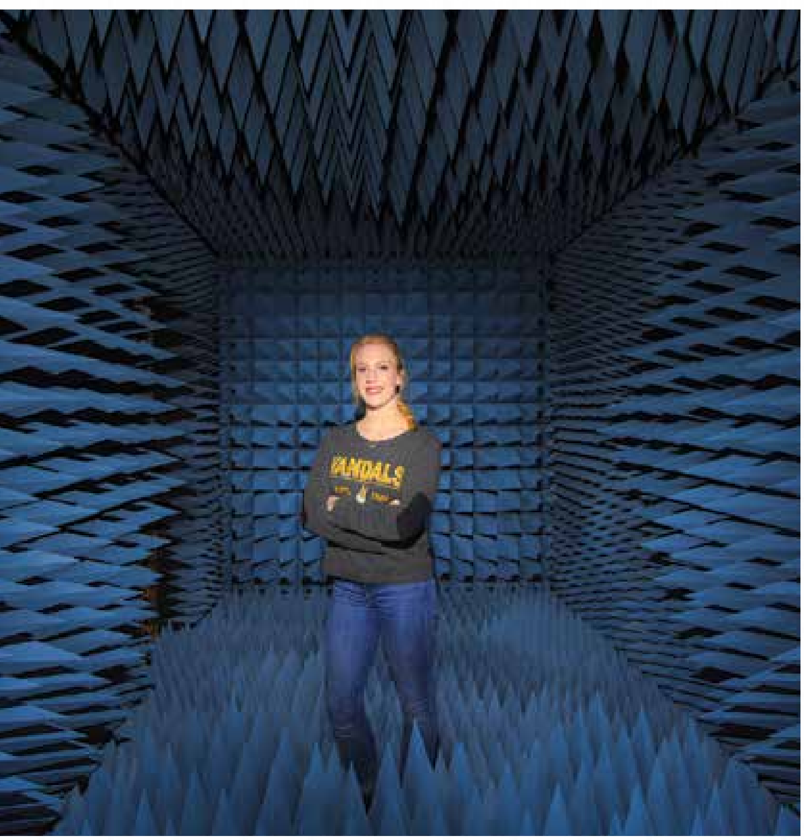


Photo by University of Idaho

May: Kipp Coddington, University of Wyoming, *The Low-Carbon Energy Transition: Some Observations Regarding Possible Impacts for the Rocky Mountain Region*

June: Lan Li, Boise State University, *Combining Computational Modeling and Artificial Intelligence to Accelerate Nuclear Materials Development*

July: Steve Herring, Center for Space Nuclear Research, *Exploring the Connection Between Nuclear Energy and Space Research*

August: Keith Weber, Idaho State University, *Getting a Handle on Wildfires with GIS*

September: Lara Pierpoint, Exelon, *Innovation in the Electricity Sector*

CAES pilots CAES Currents, a public forum focused on current events

CAES hosted a public forum on the recent fires in the Amazon rainforest in mid-September. The event was moderated by CAES Associate Director for Idaho State University Dave Rodgers and featured experts from several CAES entities, including Idaho National Laboratory, Idaho State, and University of Wyoming. The discussion focused on the potential long-term impacts of the fires and what can be done to mitigate those impacts. CAES leadership intends to regularly hold these public forums - called CAES Currents - focusing on current events when representatives from the CAES entities have relevant expertise. The goal is to provide a forum for the CAES community - students and faculty at the CAES universities, INL researchers and the public - to gain insight into the topic, discover opportunities and solution-based outcomes, and increase dialogue among the CAES affiliates in the hopes of generating or furthering collaboration and education among them.

OUTREACH

Director Testifies on Capitol Hill

In March, CAES Director Noël Bakhtian testified before the US House Appropriations Subcommittee on energy workforce opportunities and challenges. In her testimony, Bakhtian highlighted the unique role that CAES plays in conducting cutting-edge energy research, educating the next generation of scientists and engineers, and partnering with industry to advance competitiveness. She also highlighted how CAES can meet the needs of a shifting energy workforce and the importance of robust federal support for CAES' efforts.

Idaho Board of Education briefed on CAES

The Idaho State Board of Education received a briefing on the work under way at CAES and the growing research/education/innovation campus consisting of CAES and new buildings housing the Collaborative Computing Center and Cybercore Integration Center, both of which opened in October 2019.

City of Boise Partners with the Energy Policy Institute andIdaho Policy Institute:

The City of Boise recently adopted a target to derive 100 percent of its electricity from clean energy by 2035, a decision informed by research completed by the CAES Energy Policy Institute and Idaho Policy Institute, both based at Boise State University. The two institutes surveyed Boise residents' priorities and practices in areas such as energy savings and fuel sourcing. Among the findings, results showed that 57.5% of respondents strongly agreed with the city's goals to reduce energy use and transition to clean/renewable energy.


Dr. Kathleen Araújo

CAES Energy Policy Institute staff conducts energy training for Mandela Washington Fellowship

CAES Energy Policy Institute (EPI) instructors at Boise State University supported training over the summer for fellows in its Mandela Washington Fellowship for Young African Leaders Program. Dr. Kathleen Araújo, EPI Director, and EPI Senior Research Associate Stephanie Lenhart trained approximately 25 young leaders from the public- and private sector in Sub-Saharan Africa on energy decision-making as part of a six-week training program managed in part by the U.S. Department of Education.

CAES Energy Policy Institute hosts 9th annual conference

The CAES Energy Policy Institute at Boise State University held the 9th annual Energy Policy Research Conference. The theme of the three-day event was "Energy Decision-Making in Times of Disruptive Change," and it focused on the ways in which energy policy is framed, influenced, and evaluated in an era of disruptive change. More than 150 people registered for the event, which included keynote speaker Carol Battershell, the Principal Deputy Director in the Department of Energy's Office of Policy; Mitch Colburn, Resource Planning and Operations Director for Idaho Power; Barbara Lockwood, Vice President of Regulation for Arizona Public Service Company; Boise State University President Dr. Marlene Tromp; and CAES Director Noël Bakhtian. EPI's annual conference examines the drivers and impacts of policy in energy-related systems, allowing attendees to explore issues and opportunities while fostering in-depth cross-cutting exchanges of ideas. It brings together leading researchers, policymakers, industry practitioners, students, and members of the private sector. The conference drew international attendees, including John Kotek, Vice President of Policy Development and Public Affairs with the Nuclear Energy Institute; Zachary Tudor, Associate Laboratory Director at Idaho National Laboratory;

Desmarie Waterhouse, Vice President of Government Relations and Counsel for American Public Power Association; Martin Young, Director of Policy and Risk at World Energy Council; Fouad Khan, Associate Editor for Nature Energy journal; and Steve Hammer, Advisor for World Bank.

CAES represented at climate conference

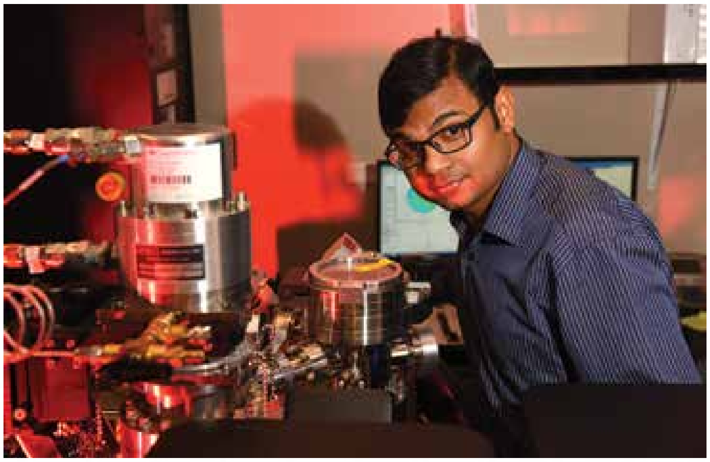
Two CAES-affiliated researchers spoke at a climate conference in New York City in June: Kipp Coddington, Director of Energy Policy & Economics at University of Wyoming's School of Energy Resources, participated in a panel discussion on carbon-dioxide removal at the conference, *Beyond Electricity: Climate Change and the 75% Problem*, and Anne Gaffney, Chief Science Officer for INL's Energy and Environment Science and Technology Directorate, took part in a panel discussion focused on industrial production. Held at AAAS Headquarters in New York City, the conference examined the challenges and potential solutions available in areas in which decarbonization is less obvious than in the electricity sector, where technology and policy options abound, and it featured several high-profile speakers, including former Department of Energy Chief Financial Officer Joe Hezir, now with Energy Futures Initiative; Jacqui Patterson, the Environmental and Climate Justice Program Director at the NAACP; and Kathleen Hogan, former Deputy Assistant Secretary for Energy Efficiency in the DOE Office of Energy Efficiency and Renewable Energy.

CAES represented at energy conference

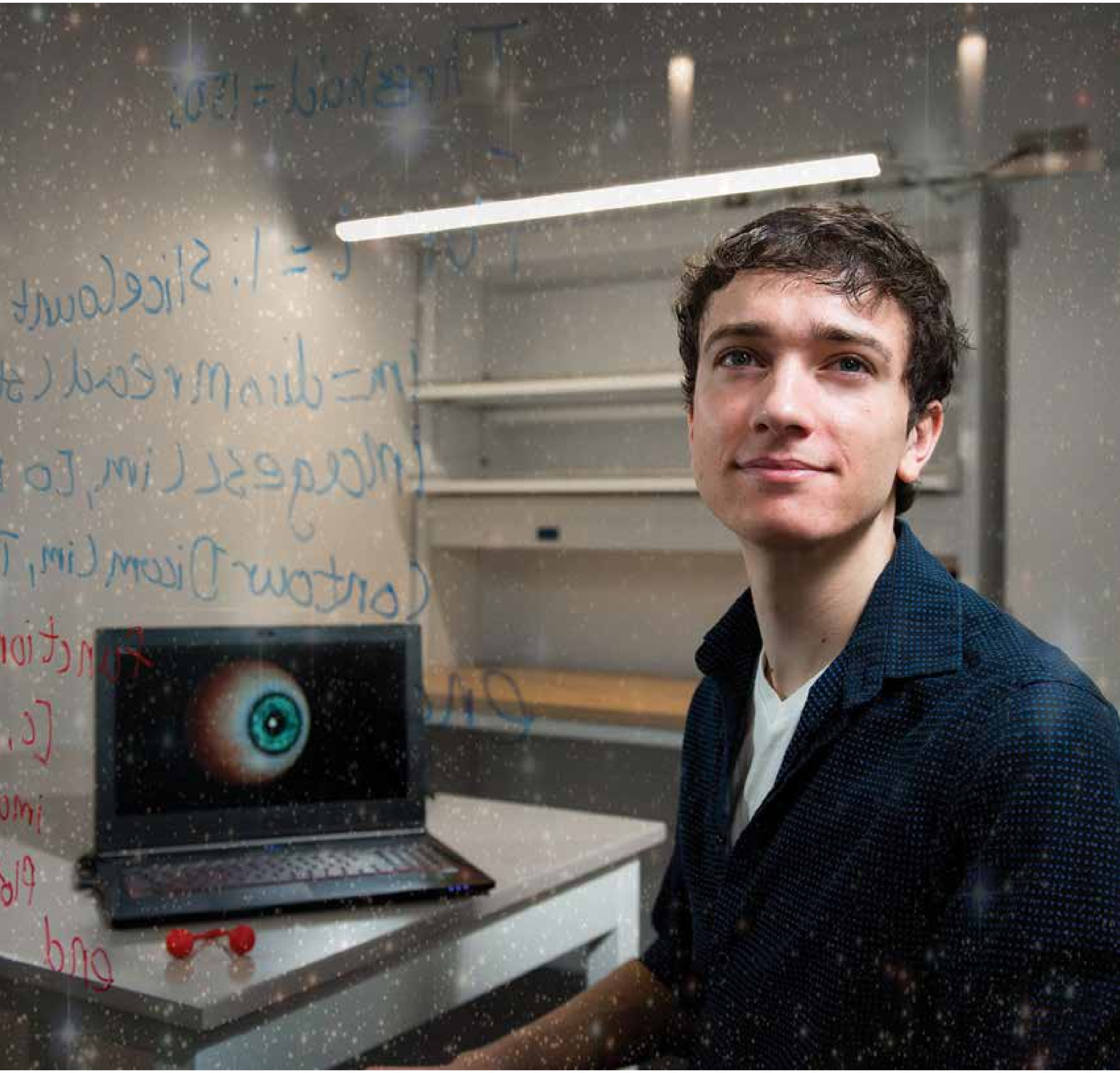
CAES was an exhibitor at the Powering the Future: Energy in the West conference in Boise in late August. The event featured more than 30 presenters from eight states, including CAES Energy Policy Institute Director Dr. Kathleen Araújo, who led a panel discussion at the conference titled The Role of the Science Enterprise and Innovation in Energy Transitions. Among the panelists were Dr. JoAnn Lighty, Dean of Boise State University's College of Engineering, and Dr. John Russell, CAES Associate Director for University of Idaho. Araújo's presentation was called Energy Jobs and Innovation Hubs in Energy Transitions.

CAES invited to inaugural energy summit

CAES was invited to participate in the inaugural University Energy Institute Leadership Summit in Pittsburgh in late September. The summit was sponsored by the Advanced Research Projects Agency-Energy and the Alfred P. Sloan Foundation and focused on the importance of creating and maintaining open channels of communication in order to tout the knowledge and innovation in the energy and environment fields at the nation's universities.



Publications and Proceedings



PUBLICATIONS AND PROCEEDINGS

In fiscal year 2019, CAES-affiliated students, researchers, and faculty from the CAES member organizations published 197 papers, journal articles, reports, and conference proceedings. The following pages include an alphabetized list of the CAES publications and proceedings as reported by each organization's CAES associate director.

Boise State University

1. Araujo, K., Boucher, J., Aphale, O. *A Clean Energy Assessment of Early Adopters in Electric Vehicles and Solar Photovoltaic Technology,* Journal of Cleaner Production.
2. Araujo, K. Distributed generation panel at Association of Public Policy and Management, Fall Conference, Washington DC, November 10, 2018.
3. Araujo, K. Hybrid systems meetings at IAEA, October 22, 2018.
4. Araujo, K. Geothermal Resources Council Annual Meeting, Reno, NV, October 14-17.
5. Araujo, K. Scientific Advisory Board Member for International Energy and Society Conference.
6. Aruajo, K., Boucher, J., Aphale, O. *A Clean Energy Assessment of Early Adopters in Electric Vehicle and Solar Photovoltaic Technology*, Journal of Cleaner Production, 216, 99-116.
7. Araujo, K., Larson, B., Fry, V., Osterhout, G. *Urban Energy Planning: Policy through Consultative Surveys*, Energy Policy Research Conference paper.
8. Araujo, K. Geothermal Resources Council Annual Meeting: Moderated panel on opportunities and challenges for the geothermal industry.
9. Araujo, K. Energy in the West conference: Keynote speaker on regional innovation systems and energy jobs; moderated panel on the role of the science enterprise in energy transitions.
10. Araujo, K. Sun Valley Forum: Speaker on international energy transitions; panelist on energy.
11. Araujo, K., Larsen, B., Osterhout, G., Crossgrove-Fry, V. *Boise's Energy Future: Survey and Technical Report*, to inform Boise City Council's decision to adopt 100% clean electricity targets by 2035.
12. Babinkostova, L., Pansera, B.A. *Selective versions of theta-density*, Topology and its Applications 258 (2019), 268 – 281.
13. Bahr, C., Kim, Y.H., Neyman, E., Taylor, G.K. *Anomalous Primes and the Elliptic Korselt Criterion*, Journal of Number Theory (2019), in press.
14. Estrada, D., Pandhi, T., Kreit, E., Aga, R., Fujimoto, K., Mohammad, S., Khademi, S., Chang, A.N., Xiong, F., Koehne, J., Heckman, E.M. *Emerging 2D Nanomaterials for Additive Manufacturing of Space-Grade Flexible Electronics*, 69th International Aeronautics Congress (IAC), (Bremen, Germany; Oct. 2018)
15. Estrada, D. *Emerging Materials for Additive Manufacturing of Flexible Hybrid Sensors*, Americas International Meeting on Electrochemistry and Solid State Science (Cancun, Mexico)
16. Estrada, D. *Graphene as Biomaterial for Defense Applications*, International Society for Optics and Photonics (SPIE) Security and Defence Conference (Berlin, Germany)
17. Estrada, D., Hollar, C., Fleming, A., Davis, K., Budwig, R., Jensen, C. *A Parametric Study of a Transient, Multilayer Analytical Model of In-Pile Thermal Conductivity Measurements using the Needle Probe*, International Journal of Thermal Sciences, 145, 106028 (2019).

18. Estrada, D., Hollar, C. Fleming, A., Davis, K., Budwig, R., Jensen, C. *A Parametric Study of a Transient, Multilayer Analytical Model of In-Pile Thermal Conductivity Measurements using the Needle Probe*, International Journal of Thermal Sciences, in revision.

19. Estrada, D., Hollar, C., et al. *High-Performance Flexible Bismuth Telluride Thin Film from Solution Processed Colloidal Nanoplates*, ACS Applied Energy Materials, in review.

20. Estrada, D., Varghese, T., Dun, C., Kempf, N., Saeidi-Javash, M., Richardson, J., Zhang, Y. *Bulk Like Thermoelectric Performances of Flexible Devices by Scalable Printing and Liquid-Phase Sintering*, ACS Energy Letters, in review.

21. Estrada, D., Fujimoto, K., Unruh, T., Fujimoto, A., Cornwell, C., McMurtrey, M., Subbaraman, H. *Aerosol Jet Printing o In-Pile Passive Temperature Sensors*, International Conference on Advancements in Nuclear Instrumentation Measurement Methods and Applications (ANIMMA), (Portoroz, Slovenia; Jun. 2019).

22. Estrada, D., Fujimoto, K., Pandhi, T., Mansoor, N-e, Muramutsa, F., Subbaraman, H. *Emerging Nanomaterial Inks for Additive Manufacturing of Wearable Sensors*, 235th Electrochemical Society Meeting, (Dallas, TX)

23. Estrada, D., Mansoor, N-e, Muramutsa, F., Schuck, C., Subbaraman, H., Pandhi, T., Gogotsi, Y. *Aerosol Jet Printing of Ti3C2 MXene Aqueous Ink*, 235th Electrochemical Society Meeting, (Dallas, TX)

24. Estrada, D., Hollar, C., Fleming, A., Davis, K.L., Budwig, R., C. Jensen, C. *Analytical Modeling of In-Pile Thermal Conductivity Measurements Using a Line Heat Source*, International Conference on Advancements in Nuclear Instrumentation Measurement Methods and Applications (ANIMMA), (Portoroz, Slovenia).

25. Flores, A.N., Pandit, K., Dashti, H., Glenn, N. F., Maguire, K. C., Shinneman, D. J., Flerchinger, G. N., and Fellows, A. W. (2019), *Optimizing shrub parameters to estimate gross primary production of the sagebrush ecosystem using the Ecosystem Demography* (EDv2.2) model, Geosci. Model Dev.

26. Flores, A.N., Dashti, H., Poley, A., Glenn, N. F., Ilangakoon, N. T., Spaete, L., Roberts, D., Enterkine, J., Ustin, S. L., Mitchell, J. J. (2019), *A multi-method, multi-sensor approach for regional scale vegetation classification in drylands*, Remote Sensing, 11(18), 2141.

27. Flores, A.N., Sadegh, M., AghaKouchak, A., Mallakpour, I., Nikoo, M.R. *A Multi-Model Nonstationary Rainfall-Runoff Modeling Framework: Analysis and Toolbox*, Water Resources Management,

28. Flores, A.N., Dashti, H., Glenn, N.F., Ustin, S., Mitchell, J.J., Ilangakoon, N.T., Silvan-Cardenas, J., Zhao, K., Spaete, L.P., and de Graaff, M.A. *Empirical Methods for Remote Sensing of Nitrogen in Drylands May Lead to Unreliable Interpretation of Ecosystem Function, IEEE Transactions on Geoscience and Remote Sensing*, accepted.

29. Flores, A.N.,et al,. *Yamazaki, Structures and Functions of Hillslope Hydrology with Relevance to Earth System Modeling: Syntheses and Testable Hypotheses, Water Resources Research*, accepted.

30. Flores, A.N., Steimke, A.L., B. Han, B., and Brandt, J.S, *Climate Change and Curtailment: Evaluating Water Management Practices in the Context of Changing Runoff Regimes in a Snowmelt-Dominated Basin*, Water, 10, 1490.

31. Flores, A.N. Global Change Assessment Model annual science meeting, College Park, MD. Hosted by Joint Global Change Research Institute (JGCRI) of Pacific Northwest National Laboratory.

32. Flores, A. Nelsen Lecture, Syracuse University Department of Earth Sciences, *Modeling Integrated Hydro-terrestrial Environments at Human-relevant Scales*.

33. Gardner, J., Schwartz, R., Kuwada, J. *Mesh Network Communications for Robust Aggregation of Distributed Resources*, presented at the 9th Energy Policy Research Conference, Boise ID, 2019.

34. Gardner, J.F., Sukjoon, O. *Large scale energy signature analysis: Tools for utility energy efficiency programs*, Electric Power Systems Research, in review.

35. Gardner, J. CEERI Director participated in the 2019 TEDxBoise conference. *What if Fossil Fuels had Never Existed*.

36. Jankowski, E., et al. *Perspective on Coarse-Graining, Cognitive Load, and Materials Simulation. Comp. Mater*. Sci. 169, 109129 (2019).

37. Jankowski, E., Miller, E. D., Jones, M.L., Henry, M. M., Stanfill, B. *Machine learning predictions of electronic couplings for charge transport calculations of P3HT*. (2019).

38. Jaques, B., Bateman, A., Rodriguez, Y., Schoensee, L., Phero, T., Han, K.B., Nachlas, J., Steppan, J., Nair, B. *Seal ring method for high-temperature, high-pressure metal to ceramic transitions*.

39. Jaques, B., Charit, I., Kundu, A., Jiang, C. *Effect of rare earth oxides on the microstructure and mechanical behavior of Fe-Cr based alloys processed via spark plasma sintering*.
40. Jaques, B., Kundu, A., Jiang, C., Sittiho, A., Charit, I. *Development of Fe-9Cr Alloy via High Energy Ball Milling and Spark Plasma Sintering for Fast Reactor Fuel Cladding Material*. Submitted to the Journal of Nuclear Materials. 18 December 2018.
41. Jaques, B., Kundu, A., Instasi, S., I. Charit, I., and Jiang C. *A Preliminary Study on the Development of a Fe-9Cr Model Alloy via High Energy Ball Milling and Spark Plasma Sintering*. Submitted to the Journal of Alloys and Compounds (06 November 2018).
42. Jaques, B. 2018 University Turbine Systems Research Project Review Meeting. Daytona, FL. October 31, 2018. B.J. Jaques co-presented *Development of a Novel Ceramic-to-Metal Seal for High-Temperature, High-Pressure Applications*.
43. Jaques, B., et al. Materials Science and Technology 2018 Conference. Columbus, OH. October 14-18, 2018. B.J. Jaques authored or co-authored 3 presentations: Oxidation behavior of Zr-alloy cladding candidates for the TREAT reactor LEU fuel core.
44. Jaques, B., Rodriguez, Y., Phwero, T.L., Schoensee, L., Bateman, A., Han, K.B., Steppan, J., Nachlas, J. Poster presentation: *Diffusion Studies for Ceramic-to-Metal Joining for Heat Exchanger Applications*. Materials Science and Technology 2018 Conference. Columbus, OH. October 14-18, 2018.
45. Jaques, B., Lupercio, A.E., Watkins, J.K., Foster, J.G. Poster presentation: *Transverse Rupture Strength of Ceria as a Surrogate Nuclear Fuel*. Materials Science and Technology 2018 Conference. Columbus, OH. October 14-18, 2018.
46. Jaques, B., Butt, D.P., Watkins, J.K. *Hydrothermal Corrosion of UN and UN-UO2 Nuclear Fuels*. Journal of Nuclear Materials. Vol. 518, pp. 30-40, 2019.
47. Jaques, B. 11th annual Nuclear Plant Instrumentation, Control and Human-Machine Interface Technologies (NPIC-HMIT 2019) Conference. Orlando, FL. February 9-14, 2019. Jaques was a panelist for the In-Pile Instrumentation Development for Test Reactor Experiments Panel.
48. Jaques, B., Riley, S., Perrine, B., Sikorski, E., Skifton, R., Li, L. *Development and performance of high temperature irradiation resistant thermocouples*. Presented at the Materials Science and Technology 2019 Conference. Portland, OR. September 29-October 3, 2019.
49. Jaques, B., Rodriguez, Y., Phero, T., Bateman, A., Han, K., Steppan, J., Nair, B. *Study of solid-state reactions in diffusion bonded Inconel 600 to SiC with metallic interlayers*. Presented at the Materials Science and Technology 2019 Conference. Portland, OR. September 29-October 3, 2019.
50. Jaques, B., Bateman, A., Monpara. G., Fertig, R., Wu, Y. *Linking microscale experiments and modeling to predict macroscale mechanical properties in iron*. Presented at the Materials Science and Technology 2019 Conference. Portland, OR. September 29-October 3, 2019.
51. Jaques, B., Winters, R., Lupercio, A., Doyle, C., Kiggans, J., Nelson, A.T. *Synthesis and Mechanical Testing of CeO2 as a Surrogate Nuclear Fuel*. Presented at the Materials Science and Technology 2019 Conference. Portland, OR. September 29-October 3, 2019.
52. Jaques, B., Watkins, J.K., Sikorski. E., Li, L. *Improved hydrothermal corrosion resistance of UN fuel forms via addition of metallic constituents*. Presented at the American Nuclear Society (ANS) supported Top Fuel 2019: Light Water Reactor Fuel Performance Conference. Seattle, WA. September 22-26, 2019.
53. Jaques, B., et al. *Oxidation behavior of Zr-alloy cladding candidates for the TREAT reactor*. Presented at the American Nuclear Society (ANS) supported Top Fuel 2019: Light Water Reactor Fuel Performance Conference. Seattle, WA. September 22-26, 2019.
54. Jaques, B., Efaw, C.M., Reynolds, M., Vandegrift, J., Smith, K., Wu, Y., Hu, H., Xiong, H., Hurley, M.F. *Determination of Zircaloy oxide chemistry through complimentary characterization techniques*. Presented at the American Nuclear Society (ANS) supported Top Fuel 2019: Light Water Reactor Fuel Performance Conference. Seattle, WA. September 22-26, 2019.
55. Jaques, B., Lupercio, A., Doyle, C., Winters, R.C., Nelson, A.T. *Transverse rupture strength of cerium dioxide as a surrogate nuclear fuel*. Presented at the American Nuclear Society (ANS) supported Top Fuel 2019: Light Water Reactor Fuel Performance Conference. Seattle, WA. September 22-26, 2019.
56. Jaques, B.J., Li, L., Sikorski, E., Watkins, J.K. *Improved Hydrothermal Corrosion Resistance of UN Fuel Forms via Addition of Metallic Constituents*. Proceedings of the American Nuclear Society (ANS) supported Top Fuel 2019: Light Water Reactor Fuel Performance Conference, Seattle, WA, September 22-26, 2019.
57. Jaques, B.J., Vandegrift, J.L., Efaw, C., Price, P.M., Parga, C., Butt, D.P., Coryell, B., Hurley, M.F. *Oxidation Behavior of Zr-Alloy Cladding Candidates for the TREAT Reactor*. Proceedings of the American Nuclear Society (ANS) supported Top Fuel 2019: Light Water Reactor

Fuel Performance Conference, Seattle, WA, September 22-26, 2019.

58. Jaques, B., Wu, Y., Efaw, C.M., Reynolds, M., Vandegrift, J., Smith, K., Hu, H., Xiong, H., Hurley, M.F. *Determination of Zircaloy Oxide Chemistry Through Complimentary Characterization Techniques*. Proceedings of the American Nuclear Society (ANS) supported Top Fuel 2019: Light Water Reactor Fuel Performance Conference, Seattle, WA, September 22-26, 2019.
59. Jaques, B., Sikorski, E.L., DaSilca, T.H., Aegesen, L. Li, L. *First-principles Comparative Study of UN and Zr Corrosion*, Journal of Nuclear Materials, Accepted in June 2019.
60. Jaques, B., Vandergrift, J.L., Price, P.M., Van Rooyen, I.J., Morrell, S., Butt, D.P. *Oxidation Behavior of Zirconium, Zircaloy-3, Zircaloy-4, Zr-1Nb, and Zr-2.65Nb in Air and Oxygen*. Nuclear Materials and Energy. 2019.
61. Jaques, B., Charit, I., Jiang, C., Kundu, A., Sittiho, A. *Development of Fe-9Cr Alloy via High Energy Ball Milling and Spark Plasma Sintering*. The Journal of The Minerals, Metals, and Materials Society. 2019.
62. Jaques, B., Li, L., Sikorski, E., Aafesen, L. *First-principles Comparative Study of UN and Zr Corrosion*. Journal of Nuclear Materials. Sent to production June 6t, 2019.
63. Jaques, B. International conference on Advancements in Nuclear Instrumentation Measurement Methods and their Applications (ANIMMA). Protoroz, Slovenia. June 17-21, 2019.
64. Kuwada, J. and Gardner, J. *Swarm Behavior to Mitigate Demand Rebound with AC Demand Response Events*. 9-219 ASHRAE Technical Conference, Boise Idaho, 5 April 2019.
65. Lawson, M., Horn, J., Wong-Ng, W., Espinal, L., Lapidus, S.H., Nguyen, H.G., Meng, Y., Suib, S.L., Kaduk, J.A., Li, L. Invited cover paper, *First-principles study of carbon capture and storage properties of porous MnO2 octahedral molecular sieve OMS-5, Powder Diffraction*, 34, 13-20, 2019.
66. Larsen, B., Osterhout, G., Crossgrove-Fry, V. and Araujo, K., (2019). *Boise's Energy Future*, Technical Report.
67. Lawson, M., Williamson, I., Ong, Z-Y, Li, L. *First-Principles Analysis of Structural Stability, Electronic and Phonon Transport Properties of Lateral MoS2-WX2 Heterostructures*, Computational Condensed Matter, 19, e00389 (9pp), 2019.
68. Lenhart, S. presented on community-level solar in public power and rural cooperatives, Association of Public Policy and Management, Fall Conference, Washington DC, November 10, 2018.
69. Lenhart, S. *Driving Innovation for a secure and Prosperous Idaho*, sponsored by the Sun Valley Institute for Resilience; Boise, ID, October 10, 2018.
70. Lenhart, S. Joint Committee on Regional Electric Power Cooperation (CREPC)-Western Interconnection Regional Advisory Body (WIRAB) Meeting, Phoenix, AZ, October 24-26, 2018.
71. Lenhart, S., Chan, G., Forsberg, L., Grimley, M., and Wilson, E. (February 2019). *Barriers and Opportunities for Distributed Energy Resources in Minnesota's Municipal Utilities and Electric Cooperatives*, Final Research Report.
72. Lenhart, S., Nelson-Marsh, N. *An eye toward the future: Adaptive and transformative resilience in interorganizational collaborations*, submitted for special edition for the Journal of Applied Communication Research.
73. Lenhart, S., Chan, G., Grimely, M., Wilson, E. Submitted- Draft Chapter: *Comparing and contrasting the Institutional Relationships, Regulatory Frameworks, and Energy System Governance of European and U.S. Electric Cooperatives*, Routledge Handbook of Energy Democracy.
74. Lenhart, S., presented *Innovation in Community Electric Power: Constraining and Enabling Distributed Energy Resource*, International Sustainability Transitions Conference, June 2019, Carleton University.
75. Li, L. *Materials Design for Energy and Sustainability*, 2019 TMS (The Minerals, Metals & Materials Science), San Antonio, TX, Mar 2019.
76. Li, L. *Computational Discovery and Design of 2D Transition Metal Dichalcogenide Heterostructures*, 2019 TMS, San Antonio, TX, Mar 2019.
77. Li, L. *Tuning Transition Metal Dichalcogenide Heterostructure Transport Properties*, 2019 TMS, San Antonio, TX, Mar 2019.
78. Li,L., Fothergill, J. W., Hernandez, A. C., Knowlton, W., Yurke, B. *Ab-Initio Studies of Exciton Interactions of Cyanogen Dye Aggregates*, Journal of Physical Chemistry A, 122, 8989-8997, 2018.
79. Li, L., Sikorski, E.L., da Silva, T.H., Aagesen, Larry, Jaques, B. *First-principles Comparative Study of UN and Zr Corrosion*, Journal of Nuclear Materials, Resubmitted in Nov, 2018, now under revision.
80. Li, L., da Silva, T. H., Butler D., Biaggne A., Kandadai N., Subbaraman H., Daw J. *First-Principles Studies of Dopant and Radiation Defect Effects on Optical Fiber Sensors*, submitted to the peer-reviewed proceedings for 11th Nuclear Plant Instrumentation, Control and Human-Machine Interface Technologies (NPIC&HMIT) conference, now under review.

81. Li, L., Lawson, M., Horn, J., Wong-Ng, W., Espinal, L., Lapidus, S.H., Nguyen, H.G., Meng, Y., Suib, S. L., JKaduk, J.A. *First-Principles Studies of Octahedral Molecular Sieves OMS-2 and OMS-5 for Carbon Dioxide Capture and Storage Applications*, invited paper by a special issue of the journal Power Diffraction on "Crystallography and Properties of Metal Organic Framework (MOF) Compounds," now under review.

82. Li, L. *Materials-by-Design for Electronic and Energy Applications*, seminar at University of Tennessee, Knoxville, TN, Nov 2018.

83. Li, L. *Porous Manganese Dioxide Octahedral Molecular Sieve (OMS)*, 2018 MS&T (Materials Science and Technology), Columbus, OH, Oct 2018.

84. Li, L. *Strain Effect on Electrical and Thermal Transport Properties of 2D Transition Metal Dichalcogenide Heterostructures*, 2018 MS&T, Columbus, OH, Oct 2018.

85. Li, L. *Uranium Nitride Corrosion and High-Temperature Irradiation Resistant Thermocouples*, 2018 MS&T, Columbus, OH, Oct 2018.

86. Li. L. Lawson, M. Horn, J., Espinal, L., Meng, Y, Nguyen, H.G., Wong-Ng, W., Lapidus, S.H., Suib, S.L., Kaduk, J.A. Invited paper *Carbon Capture and Storage Properties of Octahedral Molecular Sieve OMS-5*, a special issue of the journal Power *Diffraction* on "Crystallography and Properties of Metal Organic Framework (MOF) Compounds," Accepted, 2019.

87. Li, L., Efaw, C.M., Da Silva, T., Davis, P.H., Graugnard, E., Hurley, M.F. *Toward Improving Ambient Volta Potential Measurements with SKPFM for Corrosion Studies*, Journal of The Electrochemical Society, 166, C1-C10, 2019.

88. Mikova, M. Presented plenary talk *Amorphous and Nanostructured Chalcogendies (ANC9)* - Chisinau Moldova June 30-July 4, 2019.

89. Scheepers, M., Pansera, B.A. *Selective versions of theta-density, Topology and its Applications 258* (2019), 268-281.

90. Sikorski, E., Da Silva, T.H., Aagesen, L., Jaques, B., Li, L. *First-principles Comparative Study of UN and Zr Corrosion*, Journal of Nuclear Materials, 523, 402-412, 2019.

91. Subbaraman, H, S. Rana, S., Kandadai, N. *Role of Metal Coating Parameters on the Reflective Long Period Grating Spectrum*, OSA Conference on Optics and Photonics for Sensing the Environment, ETH1A.5 (2019)

92. Subbaraman, H., Simon, A., Ullah, S.M.R., Badamchi, B., Mitkova, M. *Materials Characterization of Thin Films Printed with Ge20Se80 Ink*, Microscopy and Microanalysis, 25(S2), 2606-2607 (2019)

93. Williamson, M. Lawson, S. Li, Y. Chen, and L. Li, *Metal-Site Dopants in Two-Dimensional Transition Metal Dichalcogenides*, 2019 IEEE-WMED Conference Proceedings, Apr 2019, DOI: 10.1109/WMED.2019.8714147.

94. Wu, Y., Jaques, B.J., Bateman, W.A., Burns, J. *Push to Pull Method for Quantitative In-Situ TEM Tensile Testing*, in preparation. Wu, Y.

95. Wu, Y., Mao, Keyou, Sun, Perez, Emmanuel, Wharry, Janelle, P. *Laser weld-induced formation of amorphous Mn-Si precipitate in 304 stainless steel*, Materialia, 3, 174-177, November 2018.

96. Wu, Y., Burns, J., et al. *Microstructure and mechanical properties of neutron-irradiated alloy D9 and NF709 stainless steels*, submitted to The 10th International Conference on Advanced Materials and Processing, August 18-22, 2019, Xi'an, China. Wu, Y.

97. Wu, Y. et al. *Microstructure and mechanical properties of ATR-irradiated Alloy D9 and NF709*, The Nuclear Materials Conference 2018, Seattle, WA.

98. Wu, Y., Burns, J., Jaques, B. Bateman. *Push to Pull Method for Quantitative In-Situ TEM Tensile Testing*, submitted to Microscopy and Microanalysis.

99. Wu, Y., Estrada D., et al. *High-Performance Flexible Bismuth Telluride Thin Film from Solution Processed Colloidal Nanoplates*, submitted to Nano Letters. Wu, Y

100. Wu, Y., Yano, K.H., Wharry, J.P. *Size Effects in TEM in situ Cantilever Flow Stress Measurements in Irradiated Fe-9%Cr ODS*, in preparation.

101. Wu, Y., Burns, J., Chen, T., He, L., Knight, C., Sridharan, K., Xu, H. Tan, L. *Correlation between the nanoindentation mechanical properties and neutron-damaged microstructures of austenitic alloys*, TMS 2019, San Antonio, TX, USA, March 10-14, 2019.

102. Wu, Y., Patki, P., Wharry, J. *Qualitative Analysis and Modelling of Deformation in Proton Irradiated Nanocrystalline Copper Tantalum Alloy*, TMS 2019, San Antonio, TX, USA, March 10-14, 2019.

103. Wu, Y. *Microscopy and Characterization Suite at Center for Advanced Energy Studies*, submitted to ANS Student Conference 2019_ NSUF user meeting.

104. Wu, Y., Jaques, B., Bateman, A., Monpara, G. Fertig, R. *Linking microscale experiments and modeling to predict macroscale mechanical properties in iron*, submitted to MS&T 2019.

105. Wu, Y., Burns, J., Wharry, J., Patki, P., Yano, K., Warren, G., Enebechi, C., Pachaury, Y., El-Azab, A. *Nanomechanical Testing of Irradiated Nanostructured and Immiscible Alloys*, invited talk at MS&T 2019.

106. Wu, Y., Wharry, J., Warren, G., Guillen, D., Giannuzzi, L., Getto, E., Pagan, D., Freyer, P., Gandy, D. *Recent progress in testing and qualification of PM-HIP alloys for nuclear applications*, submitted to MiNES 2019.

107. Wu, Y., Patki, P., Wharry, J. *Deformation-based recovery of irradiation-induced Ostwald ripening in nanocrystalline CuTa alloy*, submitted to MiNES 2019.

108. Wu, Y., Mao, K., French, A., Pavel, M., Kroll, Z., Perez, E., Freyer, P.D., Garner, F.A., Wharry, J.P. *Characterization of High Dose Ion-irradiated Laser Weld Repairs on Neutron Irradiated Austenitic Steels*, submitted to MiNES 2019.

109. Wu, Y., et al. *Irradiation Damage Behavior in Novel High-Entropy Carbide Ceramics*, TMS 2020, accepted.

110. Wu, Y. Hoffman, A., Wen, H., Arivu, M., Islamgaliev, R., Valiev, R., He, L., Sridharan, K. *Enhanced Resistance to Irradiation-Induced Segregation and Precipitation in a Nanocrystalline Fe-18Cr-8Ni Steel*, submitted to Scripta Materialia,

111. Wu, Y., Ming, K., Gua C., Xie, D., Wang, Y., Nastasi, M., Wang, J. *Superb mechanical properties and structural stability of amorphous ceramic composites via patterning nano-spaced structure-tunable nano-heterogeneities*, in preparation.

112. Wu, Y., Van Rooyen, I. *APT Data Analysis towards Fission Products in TRISO Fuels*, APT User Conference 2019, June 18-21, 2019, Fitchburg, MI, USA. Invited.

113. Wu, Y., Wharry, J.P., Mao, K.S., Perez, E., French, A., Freyer, P.D., Shao, L., Garner, F.A. *Irradiation Effects in Weld Repairs of Irradiated Stainless Steel*, submitted to TMS 2020. Invited.

114. Wu, Y., Efaw, C.M., Reynolds, M., Vandergrift, J.L., Smith, K., Jaques, B., Hu, H., Xiong, C., Hurley, M. *Determination of Zirconium Oxide Chemistry Through Complementary Characterization Techniques*, Proceeding submitted to Top Fuel 2019. September 22-26, 2019, Seattle, WA.

115. Wu, Y., Warren, G., Warren, P., Pachaury, Y., Enebechi, C.N., Burns, J., Dubey, M., Field, K.G., El-Azab, A., Wharry, J.P. *Mechanical Properties & Dislocation Dynamics in Irradiated FeCrAl using In Situ TEM Tensile Tests*, submitted to MiNES 2019.

116. Wu, Y., et al. *Superb mechanical properties and structural stability of amorphous ceramic composites via patterning nano-spaced structure-tunable nano-heterogeneities*, Advanced Materials, submitted. Wu, Y.

117. Wu, Y., et al. *Enhanced Resistance to Irradiation-Induced Ferritic Transformation Through Nano-structuring of Austenitic Steels*, submitted to Acta Materialia, Wu, Y.

118. Xiong, C. et al. *Effect of proton irradiation on anatase TiO2 nanotube anodes for lithium-ion batteries*, Journal of Materials Science, 54 (20), 2019, 13221-13235.

119. Xiong, C., et al. *Amorphous and crystalline TiO2 nanoparticle negative electrodes for sodium-ion batteries*, Electrochimica Acta, 321, 2019, 134723.

120. Xiong, C., et al. *Defect-driven Metal Oxide Electrodes for Lithium Ion Batteries* at Symposium of Synthesis, Characterization, Modeling and Applications of Functional Porous Materials.

121. Charit, I., Shaber, N., Stephens, R., Ramirez, J., Potirniche, G.P., Taylor, M., Pugesek, H. *Fatigue and Creep-Fatigue Crack Growth in Alloy 709 at Elevated Temperatures*, Materials at High Temperatures, 36 (6) (2019) 562-574, Sept. 2019, https://doi.org/10.1080/09603409.2019.1664079.

122. Charit, I. Kundu, A., Shrestha, N., Korjenic, A., Raja, K.S. *A Study on Microstructural Evolution and Corrosion Behavior of Spark Plasma Sintered Fe-Cr Alloy System*, Journal of Materials Science, in press (2019).

123. Charit, I. Taylor, M., J. Ramirez, J., Potirniche, G., Stephens, B., and Glazoff, M. *Creep Behavior of Alloy 709 at 700 oC*, Materials Science & Engineering A, 762 (2019) 138083.

124. Charit, I. Kundu, A, Sittiho, A., Jaques, B., and Jiang, C. *Development of Fe-9Cr Alloy via High Energy Ball Milling and Spark Plasma Sintering*, JOM, in press (2019).

125. Charit, I., Goel, S., Sittiho, A., Klement, U., Joshi, S. *Effect of Post-Treatments under Hot Isostatic Pressure on Microstructural Characteristics of EBM-built Alloy 718*, Additive Manufacturing, 28 (2019) 727-737.

126. Charit, I., Webb, J., Gollapudi, S. *An Overview of Creep in Tungsten and Its Alloys*, International Journal of Refractory Metals and Hard Materials, 82 (2019) 69-80.

127. Charit, I., Morrison, M., Gould, J., Hassan, T. *Performance Evaluation of Surface Activated Solid-State Welding for ASTM A992 Structural Steel*, Journal of Materials in Civil Engineering, 31 (8) (2019) 04019168. (Editor's choice article for August issue of 2019)

128. Charit, I., Ramirez, J., Potirniche, G.P., Shaber, N., Taylor, M., Pugesek, H., Stephens, R. *The Influence of Plasticity-induced Crack Closure on Creep-Fatigue Crack Growth in Two Heat-Resistant Steels*, International Journal of Fatigue, 125 (2019) 291-298.

129. Charit, I., Taylor, M., Shaber, N., Ramirez, J., Sittiho, A., Potirniche, G., Stephens, R., Glazoff, M. *High Temperature Creep of Alloy 709: Effect of Aging*, Symposium: Deformation and Damage Behavior of High Temperature Alloys, TMS 2019 Annual Meeting, March 10-14, 2019, San Antonio, TX.

130. Charit, I., Taylor, M., Shaber, N., Ramirez, J., Potirniche, G., Stephens. *Characterization of creep-fatigue crack propagation in Alloy 709 at High Temperatures Using Computational Simulations and Experimental Testing*, Symposium: Mechanical Behavior of Nuclear Reactor Materials, TMS 2019 Annual Meeting, March 10-14, 2019, San Antonio, TX.

131. Charit, I., Kundu, Jaques, B., Jiang, C. *Effect of Rare Earth Oxides on the Microstructure and Mechanical Behavior of Fe-Cr Based Alloys Processed via Spark Plasma Sintering*, Symposium: Powder Processing of Bulk Nanostructured Materials, TMS 2019 Annual Meeting, March 10-14, 2019, San Antonio, TX.

132. Charit, I., Kundu, Jerred N.and I. *Development of Fe-9Cr ODS Alloy via High Energy Ball Milling and Spark Plasma Sintering for Fast Reactor Cladding*, 2019 Technical Division Graduate Students Poster Contest – Structural Materials Division (SMD), TMS 2019 Annual Meeting, March 10-14, 2019, San Antonio, TX.

133. Charit, I. Graves, J., Sittiho, A., Mishra, R. *Microstructure and Mechanical Properties of Al0.4CoCrFeNi High Entropy Alloy*, 2019 Technical Division Undergraduate Student Poster Contest, TMS 2019 Annual Meeting, March 10-14, 2019, San Antonio, TX.

134. Charit, I., Ayers, N., Khanal, R., Jerred, N., Benson, M., Mariani, R., Choudhury, S. *Study of Dopants in U-Zr Metallic Fuels for Limiting Fuel-Cladding-Chemical-Interaction,* 2019 Technical Division Undergraduate Student Poster Contest, TMS 2019 Annual Meeting, March 10-14, 2019, San Antonio, TX.

135. Charit, I., Khanal, R., Jerred, N., Benson, M., Mariani, R., Choudhury, S. *The Guiding Principles of the Dopants Selection to Immobilize Lanthanide Fission Products in Uranium Based Metallic Fuels*, 2019 Technical Division Young Professional Poster Contest – Structural Materials Division (SMD), TMS 2019 Annual Meeting, March 10-14, 2019, San Antonio, TX.

136. Hiromoto, R., et al. Springer Series: Advanced Control Techniques in Complex Engineering Systems: Theory and Applications. Dedicated to Professor Vsevolod M. Kuntsevich. *Toward a Secure IoT Architecture*, pp. 297-323.

137. Hiromoto, R., Williams, B., Carlson, A. The 10th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications. 18-21 September, 2019, Metz, France. Accepted to be presented on Sept. 20, 2019. *A Design for a Cryptographically Secure Pseudo Random Number Generator*.

138. Sheldon, F.T., Haney, M.A., et al. ISAAC: *The Idaho CPS Smart Grid Cybersecurity Testbed*, IEEE Texas Power and Energy Conf., College Station, TX, Feb. 7-8, 2019

139. Sheldon, F.T., Haney, M.A., et al. *Attack Scenario-based Validation of the Idaho CPS Smart Grid Cybersecurity Testbed (ISAAC)*, IEEE Texas Power and Energy Conf., College Station, TX, Feb. 7-8, 2019.

140. Sheldon, F.T., Haney, M.A., Jillepalli, A.A., D. Conte de Leon, D., I.A. Oyewumi, I.A., J. Alves-Foss, J.,B.K. Johnson, B.K., C. L. Jeffery, C.L., Y. Chakhchoukh, Y. *Formalized Automated Adversary-aware Risk Assessment for critical Infrastructure*, IEEE Texas Power and Energy Conf., College Station, TX, Feb. 7-8, 2019.

141. Sheldon, F.T., Abercrombie, R.K., Ollis, B., Abercrombie, T., Jillepalli, A. *Microgrid Disaster Resiliency Analysis: Reducing Costs in Continuity of Operations (COOP) Planning*, Proc. HICSS Jan. 7-11, 2019.

142. Beard, D.V. *Programming Languages for University Courses, In Tatnall*, A (Ed.), Encyclopedia of Education and Information Technologies. Springer 2020

Idaho State University

143. Beard, D.V. *Programming Languages for University Courses, In Tatnall*, A (Ed.), Encyclopedia of Education and Information Technologies. Springer 2020

144. Beard, D.V., Parker, K.R., Davey, B. *Teaching Computer Languages in Universities, In Tatnall*, A (Ed.), Encyclopedia of Education and Information Technologies. Springer, 2020

145. Beard, D.V., Parker, K.R., Davey, B. *Programming Language Selection for University Courses, In Tatnall*, A (Ed.), Encyclopedia of Education and Information Technologies. Springer. 2020

146. Beard, D.V. *Programming Languages for University Courses, In Tatnall*, A (Ed.), Encyclopedia of Education and Information Technologies. Springer 2020.

147. Beard, D.V., Parker, K.R., Davey, B. *Teaching Computer Languages in Universities, In Tatnall*, A (Ed.), Encyclopedia of Education and Information Technologies. Springer, 2020.

148. Beard, D.V., Parker, K.R., Davey, B. *Programming Language Selection for University Courses, In Tatnall*, A (Ed.), Encyclopedia of Education and Information Technologies. Springer. 2020.

149. Ebrahimpour, A., Mashal, M., Casanova, M., Rashique, U., Clauson, C., and Shokrgozar, A. (2018). *Effectiveness of High-Early Strength Concrete Class 50AF with Polypropylene Fibers as a Cost-Effective Alternative for Field-Cast Connections of Precast Elements in Accelerated Bridge Construction*, Idaho Transportation Department Report 265, Boise, ID, United States.

150. Grayson, B., Kerby, L. *Spherical Functional Expansions in {MOOSE}*, American Nuclear Society Winter Meeting, Nov 17-21, Washington, DC, USA. Submitted.

151. Kerby, L., Rehak, J., DeHart, M., Slaybaugh, R. *Weighted Delta-Tracking in Scattering Media*, Nuclear Engineering and Design 342 (2019)

152. Kerby, L., Mena, P. *Financial Analysis of Modular Nuclear Reactors*, Transactions of the American Nuclear Society 120 (2019).

153. Kerby, L. *Volumetric Spherical Polynomials*, American Institute of Physics Advances {\bf 9} (2019).

154. Kerby, L., Rehak, J., DeHart, M., Slaybaugh, R. *Weighted Delta-Tracking in Scattering Media*, Nuclear Engineering and Design {\bf 342} (2019).

155. Kerby, L., Juneau, C., Solomon, C. *An Overview of the Modernized Generalized Spallation Model*, American Nuclear Society Winter Meeting, Nov 17-21, Washington, DC, USA. Submitted.

156. Kerby, L., Mena, P. *Financial Analysis of Modular Nuclear Reactors*, presented at 2019 ANS Student Conference June 9 – June 13, 2019 Minneapolis, Minnesota, USA.

157. Kerby, L., Grayson, B. *Spherical Functional Expansions in {MOOSE}*, American Nuclear Society Winter Meeting, Nov 17-21, Washington, DC, USA. Submitted.

158. Kerby, L., Mena, P. *Machine Learning Accident Classification Using Nuclear Reactor Data*, American Nuclear Society Winter Meeting, Nov 17-21, Washington, DC, USA. Submitted.

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Higher Education Research Council (HERC)

Presentation to the State Board of Education

Dr. Harold Blackman, Chair

June 10, 2020

Attachments

- Statewide Strategic Plan for Higher Education Research
- Performance Measure Report
- Research Activity Report
- Infrastructure Summary Report
- Undergraduate Research Report
- Idaho Conference on Undergraduate Research
- FY20 Budget Allocation
- FY20 IGEM Fund Summaries
- FY20 Incubation Fund Summaries
- 2019 CAES Annual Report
- Draft presentation to the Board

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- Statewide Strategic Plan for Higher Education Research
- Performance Measure Report
- Research Activity Report
- **Infrastructure Summary Report**
- **Undergraduate Research Report**
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HERC Mission

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

HERC Membership

Higher Education Representatives

Dr. Bradley Ritts, *University of Idaho*

Dr. Scott Snyder, *Idaho State University*

Dr. Harold Blackman (Chair), *Boise State University*

Dr. Lori Stinson, *Lewis and Clark State College*

HERC Membership

Industry Representatives

Robin Woods, *Alturas Analytics*

Dr. Haven Baker, *JR Simplot Co.*

Marianne Walck, *Idaho National Laboratory*

Research Infrastructure

Funding to support science, engineering, and other research infrastructure

FY19 Budget - $950K

Large FY19 line items:

- **BSU** – Start-Up Funds for new hires
- **ISU** – Molecular Research Core Facility technician support
- **UI** – NKN equipment upgrades
- **LC State** – Library hardware

Undergraduate Research

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

FY19 Budget - $185K

Students supported in FY19:

BSU – 20
ISU – 10
UI – 23
LC State – 14

Idaho Conference on Undergraduate Research (ICUR)

Funding for two day conference held at BSU in late July 2019

FY19 Budget - $32K

FY19 ICUR Outcomes:

- 422 attendees from 48 different institutions/organizations
- 276 students
- 204 poster presentations
- 146 faculty, industry and governmental representatives

IDAHO CONFERENCE ON UNDERGRADUATE RESEARCH

July 22-23, 2020

Boise State University

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 $700K per year

FY19 Budget - $2,067,000

Current projects: 4

Current IGEM Projects

Sustaining the Competitiveness of the Food Industry in Southern Idaho: Integrated Water, Energy and Waste Management

University of Idaho – $1,400K – 2018-2021 (Year 2)

Nucleic Acid Memory

Boise State University – $667K – 2018-2021 (Year 2)

A Disaster Response Complex for Emergency Responders in Idaho

Idaho State University – $525K – 2019-2022 (Year 1)

Cellulosic 3D Printing of Modular Building Assemblies

University of Idaho – $175K – 2019-2022 (Year 1)

Sustaining the Competitiveness of the Food Industry in Southern Idaho: Integrated Water, Energy and Waste Management (U of I)

GRANT OVERVIEW

- Build capacity and partnerships among UI, BSU, ISU and CAES to assist Idaho food producers and processors in reducing water, energy, and waste footprints
- Demonstrate/transfer technologies for reducing water/nutrient use
- Pilot at field-scale and transfer technology for recovering valuable nutrients/byproducts from waste streams
- Provide decision support tools for community and business stakeholders to better understand the interconnections and trade-offs between energy, water, nutrients, and land use
- Include workforce development in the use of new technologies

Sustaining the Competitiveness of the Food Industry in Southern Idaho: Integrated Water, Energy and Waste Management (U of I)

GRANT PROGRESS (First half of Year 2)

- Significant progress on moving research on recovery of energy, nutrients, water and bioproducts from waste streams from the lab to the place-based pilot projects
- Measureable progress on developing and implementing decision-support tools for industry and community leaders, including improving the model of water supply/use
- Development of a decision support online tool prototype for sustainable agriculture decision-making
- Conducted pilot projects to use drones and satellite sensors to reduce water/nutrient/energy use in production of targeted crops

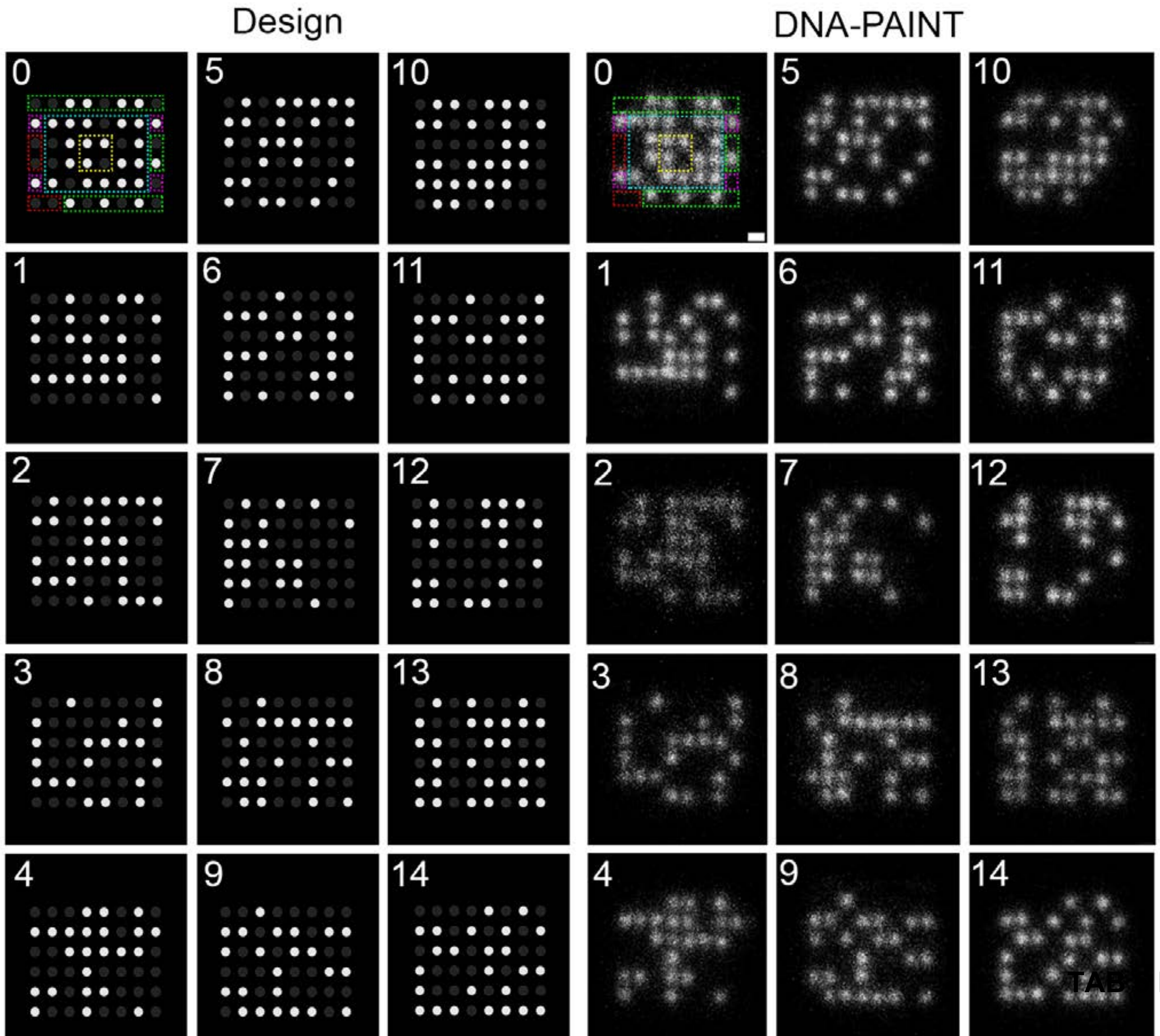
Nucleic Acid Memory (BSU)

GRANT OVERVIEW

- 16 trillion GB of data were produced in 2016; 163 trillion GB of data will be produced in 2025
- Archival storage of this huge amount of data using electronic memory is reaching physical and economic finish lines
- Project will develop an optical technology using DNA to write, store and read digital information
- DNA as a digital storage/memory medium:
  - Retention time of thousands to millions of years
  - 1 kg of DNA can store the entire projected digital universe in 2040
  - DNA storage energy is 100 million times less than current electronic memory
- Creation of Nucleic Acid Memory Institute to meet critical innovation, economic, and workforce development needs in Idaho

GRANT PROGRESS (first half of Year 1)

‘Data is in our DNA!\n’



A Disaster Response Complex for Emergency Responders in Idaho (ISU)

- GRANT OVERVIEW

- FEMA has recognized the need to establish emergency management as both an academic field and as an applied practice
- Coupling academia to traditional emergency response structures will make the complex emergency management more effective
- Goal of this project is to develop and construct an outdoor campus called “Disaster Response Complex” at ISU
- DRC will become a premier regional/national response center for research, curriculum development, and training/exercises for military and law enforcement personnel in Idaho and beyond
- The DRC ideas is strongly supported by INL and CAES who wish to use the complex to develop workforce talent

A Disaster Response Complex for Emergency Responders in Idaho (ISU)

- GRANT PROGRESS (first half of Year 1)
- Research on use of robotics and Chemical, Biological, Radiological, Nuclear, and high yield Explosives (CBRNE) markers/surrogates
- Consultation on curriculum development with INL staff
- Identification, surveying, soil sampling, permitting and groundbreaking of a physical site for the DRC in Pocatello

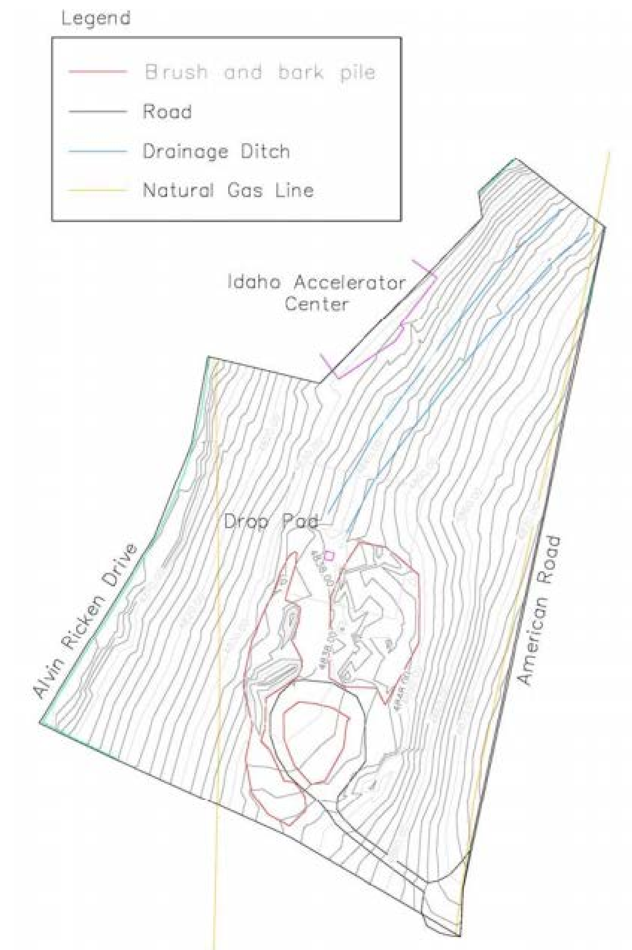


Figure 2. Surveying map of the outdoor training facility, surveyed in October 2019

Cellulosic 3D Printing of Modular Building Assemblies (UI)

GRANT OVERVIEW

- 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.

Cellulosic 3D Printing of Modular Building Assemblies (UI)

GRANT PROGRESS (first half of Year 1)

- Research on the printing mix of wood/natural fibers, binders, and adhesives
- Purchased a DHR2 Rheometer to determine cure characteristics of resins/adhesives and resin/wood blends.
- Hiring and training of key personnel
- Literature search and preliminary approach development and preliminary experiments
- Business case initial development, including market potential for this type of 3D printing

Figure 1: a) < 10 mesh, b) < 40 mesh PRF resin reinforced Douglas-Fir Wood Chips

Incubation Fund Grant Program

Competitive grant program used to develop research infrastructure, promote STEM education, foster innovation and technology, and enhance the research environment at Idaho's public institutions.

1-year grants up to $75K

FY19 Budget - $225K

Current Projects: 3

Current Incubation Fund Projects

Optical Sensors for Harsh Environment
Boise State University– $75K

Ink Production Scale Up

Boise State University – $75K

Darwin's Demons Mobile: Expanding the Market for Evolutionary Procedural Content Generation

University of Idaho – $75K

Optical Sensors for Harsh Environment (BSU)

GRANT OVERVIEW

- Market need for optical sensors that can withstand extreme environments and that are immune to electromagnetic interference
- Such sensors can be used in places like jet engines, nuclear power plants, deep see drilling rigs, etc., leading to more accurate information and increased efficiencies
- Idaho does not currently have capability to create these kinds of sensors locally
- Fiberguide Industries in Caldwell would like to partner with BSU and become the industry leader in the US for this technology
- This grant will allow BSU to purchase an ultrafast laser system purchase that will be used by researchers and Fiberguide staff to create sensors on specialty fibers and test them under harsh environments (extreme temperature and radiation)

Optical Sensors for Harsh Environment (BSU)

GRANT PROGRESS

- Purchase order for ultrafast laser system was placed and laser arrived at BSU in early 2020
- Further research is on hold due to coronavirus pandemic

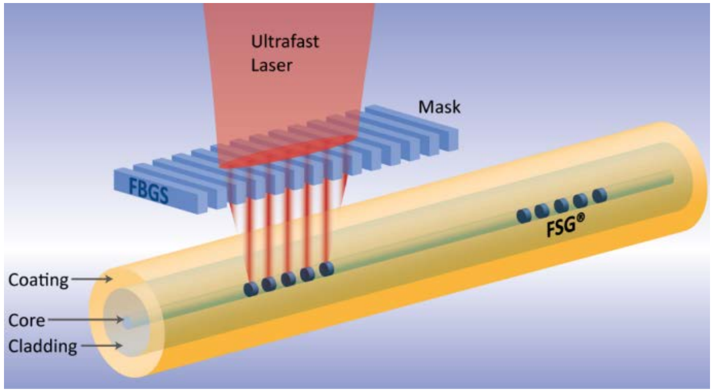


Illustration of specialty sensors being created using an ultrafast laser system

Ink Production Scale Up (BSU)

GRANT OVERVIEW

- Scale up the synthesis of nanoparticle inks
- Several inks are not available commercially, including platinum, niobium, cobalt, tungsten, molybdenum, iron
- Great interest in these inks from industry, national labs, and governments
- Further foster partnerships with industry, leading to commercialization of new inks and associated technologies

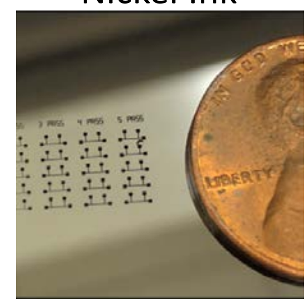
Ink Production Scale Up (BSU)

Platinum Ink

GRANT PROGRESS

- Two research hires
- 2 major equipment purchases
  - RheoSense Microviscometer
  - Tangential Flow Filtration System
- 3 Colloidal nanopartical-based inks developed →
- 3 2D nanomaterials-based inks developed
- Multiple conducive, semiconducting and thermoelectric inks under development
- 1 NanoInk contract approved by BSU
- 2 contracts in preparation

Nickel Ink



Zinc Oxide Ink

Darwin’s Demons Mobile: Expanding the Market for Evolutionary Procedural Content Generation (UI)

GRANT OVERVIEW

- US video game market generates over $90B per year
- Content development for games is expensive
- In a previous IGEM grant, UI researchers created a game using evolutionary procedural content generation (IPCG)
- This approach uses evolutionary models to evolve game content rather than relying on pre-programmed content
- IPCG creates a competitive advantage by significantly reducing game development costs
- This grant will allow UI to develop a mobile version of the game developed using IGEM funds (called Darwin’s Demons)
- The mobile market is very large potential source of income

Darwin's Demons Mobile: Expanding the Market for Evolutionary Procedural Content Generation (UI)

GRANT PROGRESS

- Hired lead artist and game developer
- Hired development team
- Developed game into a playable beta stage for Apple and Android devices
- Registered with Google Play store for sale
- Registered with Apple App store
- Developed micro-transaction business model and incorporating it into the game's architecture

FY20 HERC Budget Allocation

IGEM	$2,066,500
Infrastructure Funds	$850,000
Matching Grants (EPSCoR Match)	$800,000
Incubation Fund	$244,670
Undergraduate Research	$217,000
Administrative Costs	$2,700
Total -	**$4,160,870**

Thank You

Idaho State Board of Education