

INSTITUTE FOR BIOINFORMATICS
AND EVOLUTIONARY STUDIES

IBEST



ANNUAL REPORT

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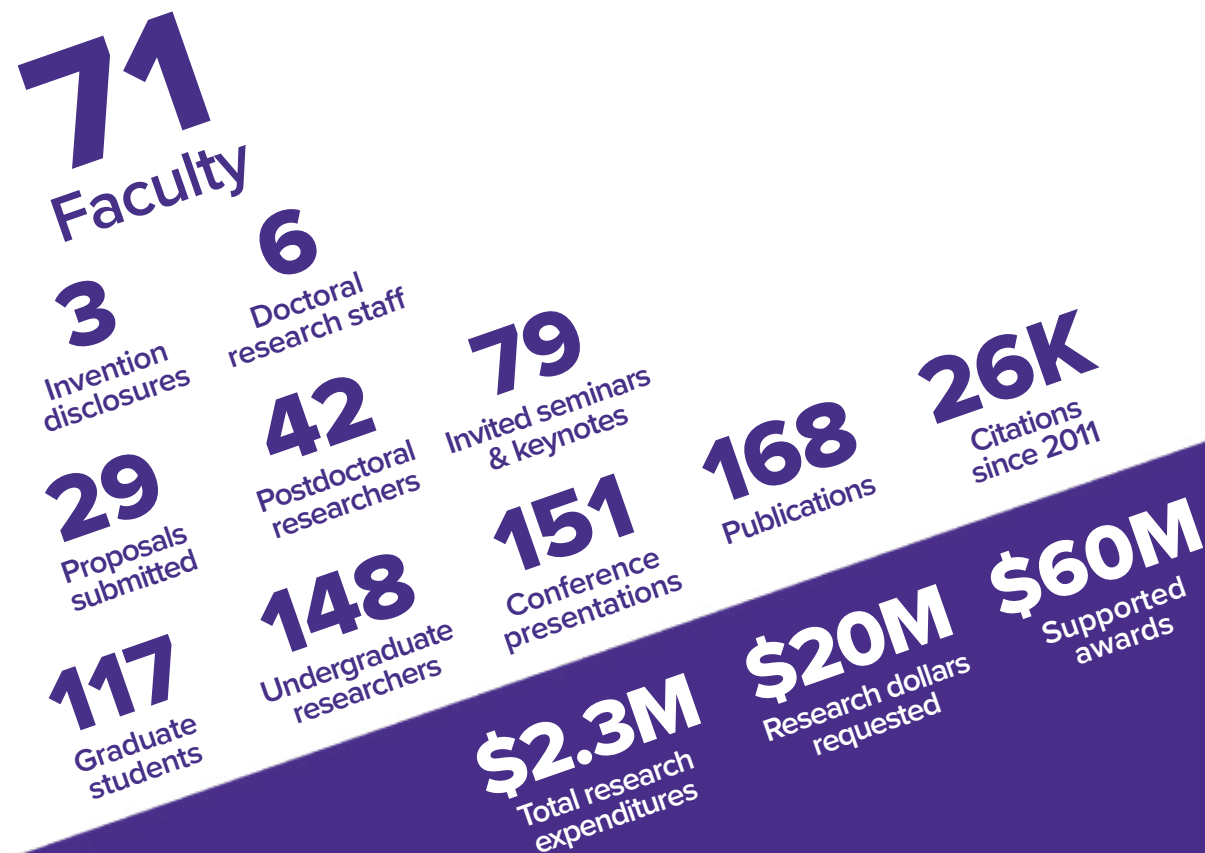
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EXECUTIVE SUMMARY

The Institute for Bioinformatics and Evolutionary Studies (IBEST) is a level III Research Institute at the University of Idaho. IBEST's mission is to empower University of Idaho researchers to understand and apply the evolutionary process. To do this, IBEST invests in personnel and infrastructure that allow students, postdocs, and faculty to maximize their research productivity. This report describes the accomplishments of IBEST participants in the 2019 fiscal year, as well as IBEST's structure, resources, and strategic vision. IBEST is a vibrant home for interdisciplinary research, with student, postdoc, and faculty participants from 8 colleges and 33 departments at the University of Idaho. These participants engage with IBEST in a variety of ways, including proposal support, grant management, and usage of genomics, bioinformatics, computational, and data storage infrastructure.

IBEST participants contribute significantly to the University of Idaho's Strategic Plan goals. In FY19, faculty submitted 29 proposals through IBEST, requesting a total of ~\$20 million. Of these requests, ~\$1.2 million has been awarded and ~\$4.6 million of these requests remain pending. Total FY19 research expenditures from IBEST managed grants were \$2.3 million.

Faculty participating in IBEST report 168 publications in 2019 along with 151 conference presentations and 79 invited research presentations or keynote addresses. These faculty also represent a significant impact on the University of Idaho's training mission, mentoring 148 undergraduates, 117 graduate students, and 42 postdoctoral scholars.



IBEST PLAYS AN ESSENTIAL ROLE IN BUILDING RESEARCH CAPACITY AT THE UNIVERSITY OF IDAHO

The faculty, students, and postdocs who participate in IBEST activities had a truly remarkable year. By my informal count, there are 10 different active NIH R01 grants on the UI campus—an institutional record. Of these awards, all but one relied on IBEST infrastructure in either the pre-award or post-award phase. IBEST faculty report 168 publications in 2019, bringing the Institute's total to 930 papers published since 2011. These papers have been collectively cited 26,705 times. According to Web of Science, the state of Idaho has four highly cited researchers. All four are at the University of Idaho, and three of the four (Luke Harmon, Paul Hohenlohe, and John Abatzaglou) rely extensively on IBEST infrastructure. The University of Idaho is clearly and unequivocally delivering significant return on the NIH investment that helped create IBEST.

Despite the University's current financial restructuring, IBEST continues to invest time and energy to further strengthen the University's research mission. For example, we have begun a cover initiative that seeks to help faculty get their work featured on journal covers, with the aim of increasing the readership of IBEST-related publications. As we continue to invest in new infrastructure for

genomics, computation, and data services, we will further broaden the campus-wide impact of IBEST and find creative ways to spark new collaborations.

Although this as an exciting time for the IBEST community, important challenges remain. Chief among these is maintaining the infrastructure built by the capacity-building grants awarded to UI from the National Science Foundation and the National Institutes of Health. The expectation from research capacity-building grant programs (such as Dr. Forney's COBRE) is that the recipient university will continue to support the research infrastructure capitalized by federal investment. In the case of IBEST, that infrastructure is related to research computing (the CRC) and genomics (the GRC). Unfortunately, UI's strategy for sustaining this infrastructure has been *ad hoc* and is not sustainable in the long term. We've done our best, but if UI is to attain R1 status, we simply must come up with a coherent institutional strategy for investment and maintenance of research infrastructure. This includes supporting the staff that provision it, creating a fund for refreshing and modernizing it, and devising a strategy for new investments. In this regard, I am very encouraged by President Green's commitment to research and the role it plays in the education and economic development of our state. In the coming year, I hope you will join me in advocating for the research infrastructure upon which we all depend. IBEST has accomplished great things, but our efforts together are essential to maintain that capacity in the face of our current shared challenges.



LETTER FROM THE DIRECTOR

Dr. Barrie Robison
IBEST Director

MISSION

IBEST empowers researchers to understand and apply the evolutionary process.

VISION

IBEST aspires to be a globally recognized center of excellence in evolutionary science that:

- » Facilitates high impact research in evolutionary science
- » Helps the UI attract and retain world class faculty, staff, and students
- » Provisions cutting edge research infrastructure for genomics, bioinformatics, and computation

THE CENTRALITY OF EVOLUTION TO UI'S LAND GRANT MISSION

IBEST PROVIDES AN INTERDISCIPLINARY, COLLEGIAL AND INCLUSIVE ENVIRONMENT DEFINED BY A SHARED COMMITMENT TO UNDERSTANDING AND APPLYING THE EVOLUTIONARY PROCESS.

The process of evolution is the unifying principle of the life sciences and is central to many components of the University of Idaho's Land Grant Mission. Understanding evolution is essential to improving human well-being because evolutionary processes drive critical health challenges such as emerging infectious diseases, antimicrobial resistance, and even the origin and treatment of diseases such as cancer, mental illness, and obesity. Evolution also underlies agricultural challenges such as the emergence of pesticide resistance, the effects of invasive species, and improving the effectiveness of domestication.

Understanding evolution also helps us protect our natural heritage by informing conservation policy and providing insight into adaptation to changing environments. Less obviously, computers can use evolution to solve complicated problems and to design both software and hardware. Evolutionary models have even proven important to understanding the diversity of languages and cultures.

The Institute for Bioinformatics and Evolutionary Studies (IBEST) is a Level III Research Institute at the University of Idaho that empowers researchers to understand and apply the evolutionary process. At IBEST, our goal is to maximize the **RESEARCH IMPACT** of participating faculty.

HIGH IMPACT RESEARCH INFLUENCES HOW PEOPLE THINK ABOUT THE WORLD.

THERE ARE MANY DIFFERENT WAYS THAT RESEARCH CAN HAVE IMPACT

BASIC	RESEARCH IMPACT
GENERATIVE	Broadly applicable, generates new ideas
BRILLIANT	Thoughtful, creative, and visionary
EXPLANATORY	Provides valuable understanding
USE-INSPIRED	Motivated and informed by societal issues
ENGAGED	Carried out in partnership with society
PRACTICAL	Quickly solves a specific practical problem
APPLIED	

CATALYZING THE RESEARCH PROCESS

THE IBEST LOGIC MODEL

In order to best understand how to maximize research impact of participating faculty, IBEST has developed a logic model for the research process. In this logic model, we break the research process into a series of “states”, beginning with a nascent idea and culminating with the scholar’s intended (or unintended) impact. These states are common milestones through which a research project can typically traverse and mirror the steps in the scientific method.

Most research begins as an **IDEA**. Over time, the researcher refines the idea until it can be formalized as a hypothesis within a research **PROPOSAL**. These proposals are often framed as requests for **RESOURCES**, which usually come in the form of funding. Research resources, however, are merely the means to an end. The resources are spent on personnel, supplies, and equipment in order to collect and **DISCOVER** data, which is then synthesized and **DISSEMINATED** to the research community. The most typical “state” at this stage of the model is a publication in a peer reviewed journal. Ultimately, though, the point of the research is its intended **IMPACT**, whether it be solving a problem or illuminating the processes that govern the world around us.

This model of the research process is admittedly an oversimplification. However, by envisioning the research process in this way, we can identify investments that increase the rate at which faculty can move their research forward, transitioning between the states described above. We refer to these investments as **FORCE MULTIPLIERS**.

IBEST seeks to maximize the research impact of participating faculty. This impact can take many forms, ranging from applied solutions to specific problems to basic research that illuminates the processes that govern the world around us. To understand IBEST’s focus on research impact, look no further than the review criteria for major research funding agencies.

THE NATIONAL SCIENCE FOUNDATION¹ asks its reviewers to determine the potential for the proposed research to:



- » Advance knowledge and understanding within its own field or across different fields (Intellectual Merit)
- » Benefit society or advance desired societal outcomes (Broader Impacts)

THE NATIONAL INSTITUTES OF HEALTH **significance**² score considers the following:



- » Does the project address an important problem or critical barrier to progress in the field?
- » Is there a strong scientific premise for the project?
- » If the aims of the project are achieved, how will scientific knowledge, technical capability, and/or clinical practice be improved?
- » How will successful completion of the aims change the concepts, methods, technologies, treatments, services, or preventative interventions that drive this field?

Significance is one of 5 review criteria that NIH typically uses to determine the overall impact score of a proposal – which is directly used to rank proposals and determine funding priorities.

¹ www.nsf.gov/pubs/policydocs/pappguide
² grants.nih.gov/grants/peer/guidelines_general/impact_significance.pdf

RESEARCH FORCE MULTIPLIERS

“

A capability that, when added to and employed by a combat force, significantly increases the combat potential of that force and thus enhances the probability of successful mission accomplishment.

”

- U.S. Department of Defense



AT IBEST, MOST FORCE MULTIPLIERS ARE DESIGNED TO SAVE FACULTY TIME – ALLOWING THEM TO FOCUS ON THE CONCEPTION AND EXECUTION OF THEIR RESEARCH, RATHER THAN ACTIVITIES FOR WHICH THEY WEREN’T FORMALLY TRAINED.

We consider force multipliers to be people or infrastructure that increase the rate or probability of moving research between the states in the logic model described above.

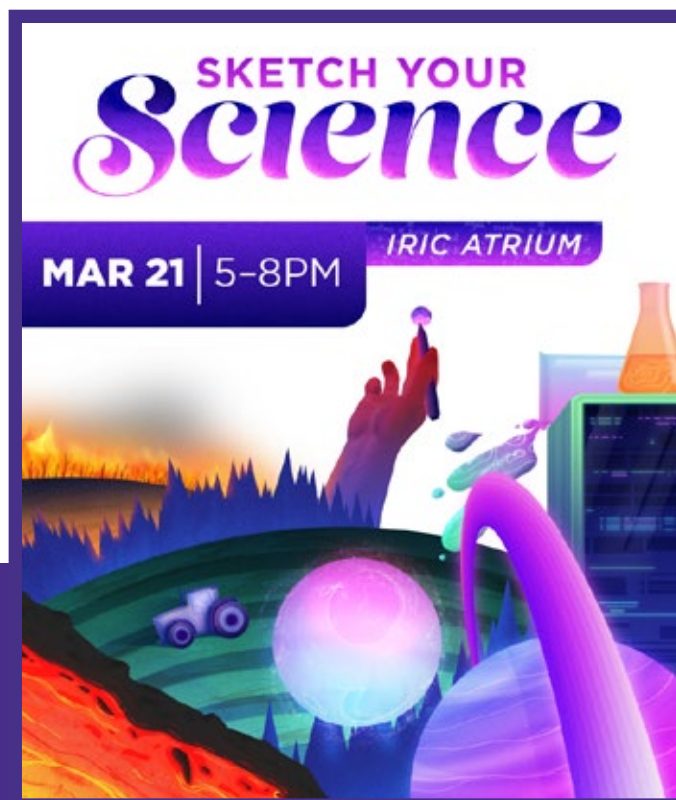
Other IBEST force multipliers provide specialized expertise or equipment that allow researchers to do things they normally couldn’t. These IBEST functions are commonly housed within our three service centers: the Genomics Resources Core, the Computational Resources Core, and the Northwest Knowledge Network. Examples of these types of force multipliers include next generation sequencing technology, bioinformatics analysis, research computing infrastructure, and data services.

THE FORCE MULTIPLIER CONCEPT originated in military history. In this context, a force multiplier is anything that increases the effectiveness of a fighting force. Examples include unique tactics, specialized equipment, or training. In more general terms, force multipliers allow an organization or individual to accomplish more with the same amount of effort.

FORMALIZING RESEARCH IDEAS

At this stage of the research process, IBEST invests in activities that help researchers refine ideas, find collaborators, and articulate their research clearly in proposals. Common strategies at this step involve connecting researchers to each other and protecting faculty time to work on articulating their science. Examples of these activities include collaborator visits, our joint seminar series, and many different forms of proposal development support.

- » **COLLABORATOR VISITS** IBEST has funded the travel costs to send faculty to visit collaborators or bring collaborators to the University of Idaho. These visits typically focus on the development of a publication or grant proposal. Support of this type is distributed at the discretion of the IBEST Director.
- » **IBEST SEMINARS** IBEST collaborates with the Institute for Modeling Collaboration and Innovation (IMCI) to offer a seminar series of up to 4 seminar visitors per semester. Speakers are nationally and internationally recognized scientists and are selected and hosted by the students in the Bioinformatics and Computational Biology Graduate program.
- » **PROPOSAL SUPPORT** One of IBEST's main tactics is to maximize the time that faculty spend on writing about their science and minimize the time the faculty spend on paperwork. IBEST administrative staff support faculty in all phases of proposal development, including RFA review, proposal initiation, budget development, document management (such as current and pending support, biosketches), sub award coordination, Cayuse and Fast Lane support, and coordination with the Office of Sponsored Programs and Office of Research and Faculty Development. These services are restricted to proposals that will be submitted through IBEST.



NEW IN FY19 IBEST hosted UI's first Sketch Your Science event, in which researchers were paired with artists to develop visualizations of their work.

GETTING PROPOSALS FUNDED

At IBEST, we try to do everything we can to increase the probability that faculty proposals are funded. Many factors enter into this process, and the needs at this stage vary considerably among investigators. In addition to protecting faculty time, we offer support for proposal pre-review, faculty development, art and graphic design, and teaching release. Other strategies at this stage are related to the generation of supporting data and new methods, typically in collaboration with one or more of our scientific service centers.

- » **PRELIMINARY DATA GENERATION** IBEST has offered a variety of mechanisms that support the collection of preliminary data for grant proposals. The two most common are Technology Access Grants (TAGS), which fund the use of either of our core facilities, or Pilot Grants, which fund personnel and supplies. The BEACON Center for the Study of Evolution in Action has also funded many faculty with seed grants intended to collect preliminary data.
- » **PROPOSAL PRE-REVIEW** IBEST funds stipends to reviewers to pre-review some proposals prior to their submission. We generally reserve this process for new investigators or large programmatic proposals.
- » **FACULTY DEVELOPMENT & MENTORING** IBEST offers workshops that build faculty skill sets. Recent examples include "Business for Scientists," in which faculty learn the fundamental concepts of pitching ideas, business models, and team management skills. We have also partnered with the College of Science, the ORED Research and Faculty Development Team, and IMCI to offer faculty development workshops related to proposal development.
- » **TEACHING RELEASE** IBEST can support teaching buyouts for faculty working on large programmatic proposals that will be submitted through the institute.
- » **ART & GRAPHIC DESIGN** IBEST staff can support the development of high-quality figures and artwork for publications and grant proposals.
- » **METHODS DEVELOPMENT** The staff in the GRC, CRC, and NKN routinely help faculty develop new research methods and write relevant pieces of methods sections for both proposals and manuscripts.



This graphic was created for Dr. Ryan Long as a result of the RFD proposal development course.

NEW IN FY19 In October, IBEST partnered with the College of Science to offer a grant writing workshop for new faculty. In spring, we partnered with ORED RFD for a cohort-based proposal development course.

SEAMLESS GRANTS MANAGEMENT

Maximizing research impact means helping researchers make the most out of every research dollar. IBEST invests in the people and infrastructure that are required to execute highly technical and cutting-edge research in genomics, bioinformatics, mathematical modeling, geospatial mapping, and data science.

- » **GRANTS SERVICES** IBEST provides post-award grant functions such as early budget setups; advance funding requests; sub-award initiation and monitoring; sponsor pre-approvals for no cost extensions, re-budgets, expenditure reviews and compliance; budget transfers; payroll cost transfers; comprehensive financial reports and project closeouts. Administrative staff also collaborate with the grants managers of various sponsoring agencies to determine appropriate actions on matters regarding modifications to contracts, re-budgeting, funding carry-forward, time extensions and other contractual terms. Working one on one with faculty researchers, IBEST staff proactively manage grant budgets by providing accurate projections and fiscal advice, and assuring compliance with institute, university, state and federal guidelines.
- » **BCB FELLOWSHIPS** IBEST has funded many BCB fellowships, which allow graduate students to work full time on funded research projects.
- » **CRC INFRASTRUCTURE** Fully described on pages 32-35, the CRC provides a variety of research computing infrastructure.
- » **GRC INFRASTRUCTURE** Fully described on pages 36-39, the GRC provides next generation sequencing and bioinformatics support.
- » **NKN INFRASTRUCTURE** Fully described on pages 40-43, NKN provides a variety of services and infrastructure related to data management, web hosting, and app development.

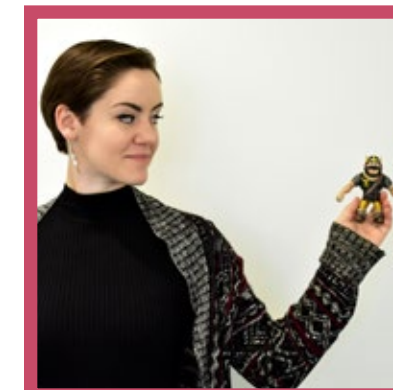


NEW IN FY19 A collaboration led by IMCI helped the UI secure the Pacific Biosciences Sequel II: a cutting-edge genome sequencing platform.

TELLING THE RESEARCH STORY

IBEST helps researchers to effectively and broadly communicate their work. This includes publications, findable, accessible, interoperable, and re-usable (FAIR) data repositories, and support for image production, visualization, and animations for print, web, and other digital media.

- » **VISUALIZATIONS** IBEST staff are available to collaborate with faculty on complex data visualizations, which can be deployed in print or online. [Online visualizations](#) can be interactive and can draw on dynamic data sets.
- » **ANIMATIONS** IBEST has supported the development of [animated visualizations](#), interactive displays, and virtual reality demonstrations that can be used for data exploration or outreach activities.
- » **PHOTOGRAPHY AND VIDEO** IBEST staff are available for [photography](#) and video production to support the dissemination of faculty and student research.



NEW IN FY19 Katy Riendeau joined the IBEST team in August, bringing a range of creative abilities with her.

INFLUENCE AND EXCELLENCE

IBEST works with investigators to promote their research results and ensure their work is consumed broadly and recognized for its excellence. Our staff help with press releases, and write articles for web and print that are published in Departmental, College, and University media. We also host symposia and other events in which faculty and students share their work.

- » **PRESS RELEASES** IBEST Administrative Staff coordinate with faculty and UI Communications and Marketing to publicize important research discoveries. This includes writing of articles and production of visual collateral.
- » **SYMPOSIA** IBEST organizes regional symposia on topics related to our research mission. These symposia typically feature distinguished keynote speakers, poster sessions, and platform presentations.
- » **SOCIAL MEDIA** IBEST publicizes events and research discoveries through social media channels.



NEW IN FY19 The Symposium on Research Computing and Data Science featured a poster session and keynote speaker Josh Hartung of PolySync.

IBEST STAFF

ADMIN



BARRIE ROBISON
IBEST DIRECTOR



LISHA ABENDROTH
PROGRAM MANAGER



MOLLYANN JONES
GRANTS SERVICES MANAGER



KATY RIENDEAU
DESIGN/MARKETING COORDINATOR

CRC



BENJAMIN OSWALD
CRC DIRECTOR



JAMES O'DELL
SYSTEMS ADMINISTRATOR

GRC



SAM HUNTER
GRC DIRECTOR



DAN NEW
GENOMICS LAB MANAGER



KIMBERLY ANDREWS
BIOINFORMATICS DATA SCIENTIST



MATT FAGNAN
RESEARCH TECHNICIAN

NKN



LUKE SHENEMAN
NKN DIRECTOR



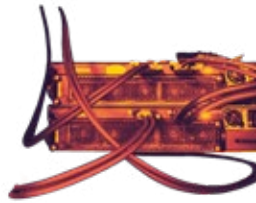
JENNIFER HINDS
RESEARCH APPLICATIONS ARCHITECT



GINA WILSON
WEB DEVELOPER



CARRIE ROEVER
ENVIRONMENTAL DATA MANAGER



ADMINISTRATION

The administrative core of IBEST performs research support functions for faculty and is an important point of interaction between IBEST faculty and other administrative units on campus. Research grant proposals may be submitted through IBEST if they pertain to evolutionary science or rely on IBEST infrastructure. Administrative staff assist the PI in proposal development, including budgets, biosketches, figures, covers, and layout. Once a grant is awarded, IBEST staff oversee purchases, travel, and other research expenditures. The Administration Core also houses large program grants like COBRE and BEACON.

COMPUTATIONAL RESOURCES CORE

The CRC provides computing services, data storage and consultation for the research community at the University of Idaho. We provide a testbed for the development and evaluation of new approaches for data analysis and modeling, at a reasonable cost. The CRC contains an advanced mix of high-performance computing clusters, powerful servers, and reliable data storage components. We staff personnel with the knowledge and technical skills required to compress years of analysis into days.

GENOMICS RESOURCES CORE

The GRC is the only comprehensive facility on the University of Idaho campus that houses all the equipment and personnel necessary to aid researchers in every aspect of high-throughput genomics research. It provides the molecular expertise and equipment needed for the most high-throughput sequencing studies, and develops partnerships with other service facilities when additional capacity or specialized equipment are warranted.

NORTHWEST KNOWLEDGE NETWORK

NKN provides research data management and computing support for UI researchers and their collaborators. We provide infrastructure and expertise to assist researchers in the acquisition, storage, and curation of quality data and metadata as well as the development and hosting of tools to support modeling, data access, and visualization. We also cultivate connections to relevant national and international data repositories. NKN's support keeps researchers on the cutting edge of data-intensive science and enhances our institutional competitiveness for external research grants that all now require formalized data management plans. The data and metadata developed by research projects and curated by NKN are a valuable, long-term asset for our public land-grant university and provide a foundation upon which to develop new research.

PARTICIPATION IN IBEST

PARTICIPATION: PRINCIPAL INVESTIGATORS

Faculty who are the most integrated in IBEST are those who submit grant proposals through the institute and/or for whom IBEST administers their budgets. In order to submit a proposal through IBEST, the research must meet one of the following criteria:

- » Aligned with IBEST's intellectual focus on evolutionary science
- » Makes use of IBEST infrastructure, including the CRC, GRC, NKN, and other research support functions.

25
FACULTY

ARE CLASSIFIED AS IBEST
PRINCIPAL INVESTIGATORS

Balemba, Onesmo

Biological Sciences
CoS

Dousay, Tonia

Curriculum and Instruction
CEHHS

Forney, Larry

Biological Sciences
CoS

Foster, James

Biological Sciences
CoS

Hamilton, Chris

Entomology, Plant Pathology & Nematology
CALS

Harmon, Luke

Biological Sciences
CoS

Hohenlohe, Paul

Biological Sciences
CoS

Johnson, Jill

Biological Sciences
CoS

Jones, Adam

Biological Sciences
CoS

Marx, Chris

Biological Sciences
CoS

Miller, Brant

Curriculum and Instruction
CEHHS

Mitchell, Diana

Biological Sciences
CoS

Nuismer, Scott

Biological Sciences
CoS

Oswald, Benjamin

IBEST
ORED

Overton, Michael

Political Science
CLASS

Parent, Christine

Biological Sciences
CoS

Ridenhour, Ben

Mathematics
CoS

Robison, Barrie

Biological Sciences
CoS

Rowley, Paul

Biological Sciences
CoS

Sheneman, Luke

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Soule, Terence

Computer Science
CoE

Stenkamp, Deborah

Biological Sciences
CoS

Sullivan, Jack

Biological Sciences
CoS

Tank, David

Biological Sciences
CoS

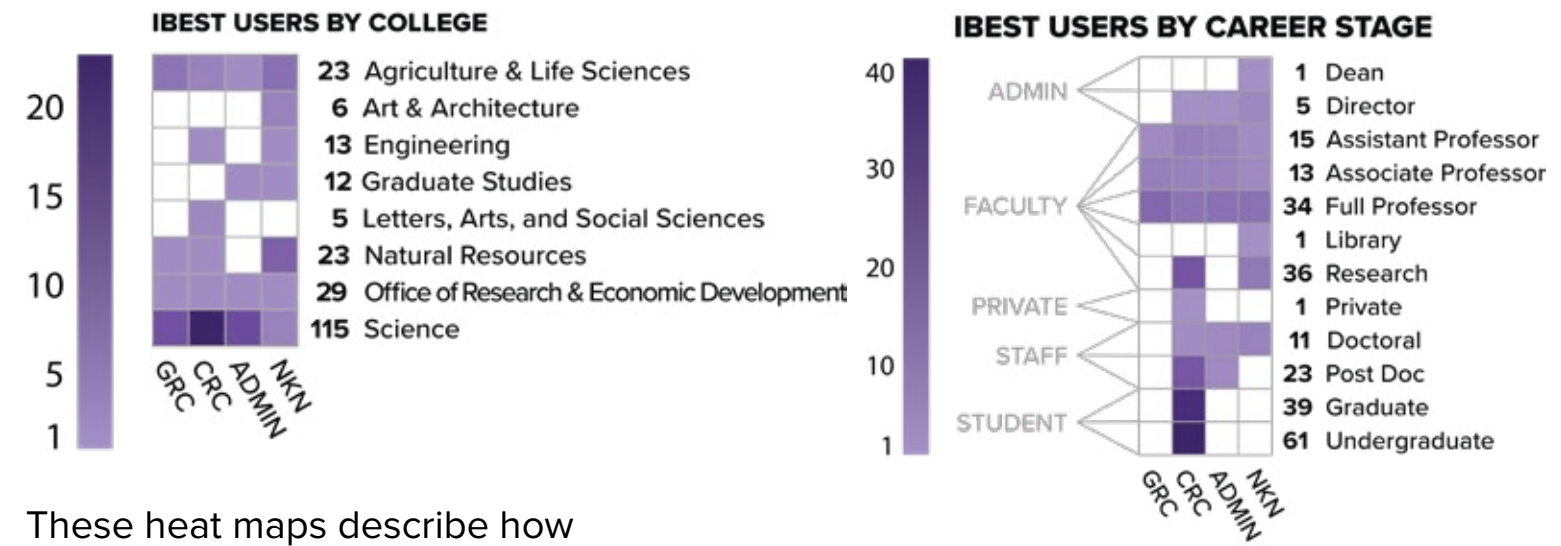
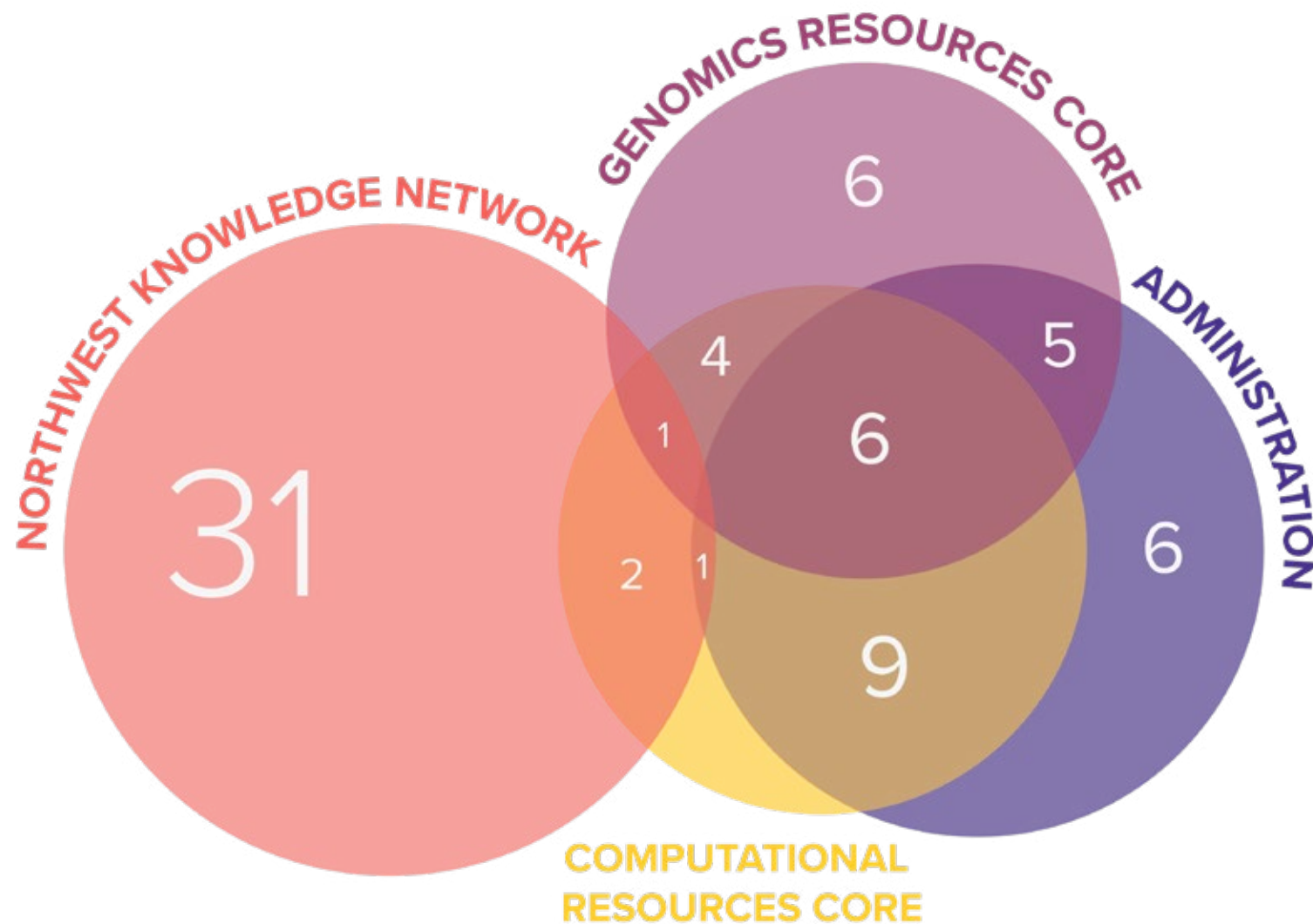
Top, Eva

Biological Sciences
CoS

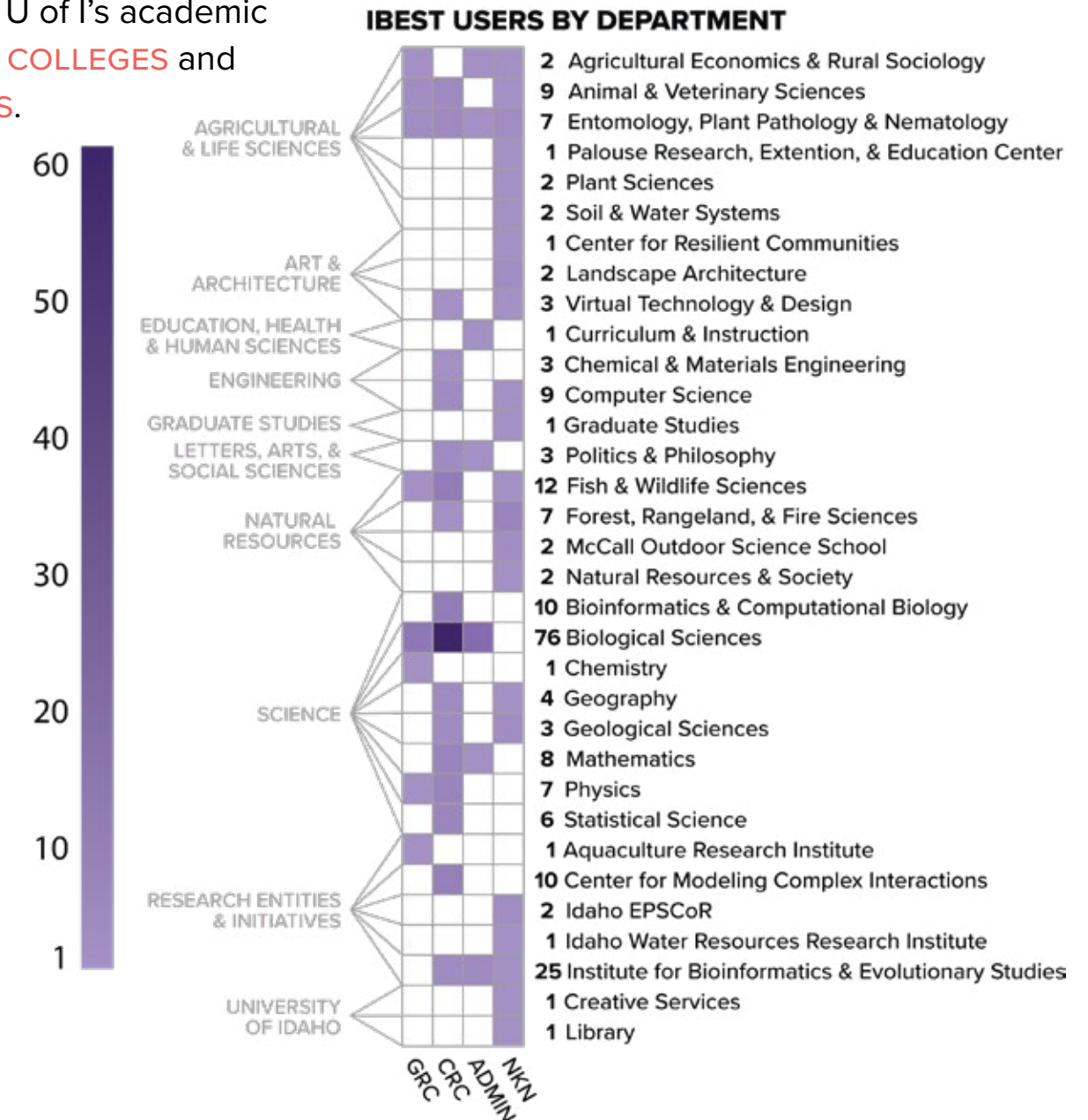
PARTICIPATION: CORE FACILITY USERS

The IBEST Core facilities support research of faculty from 8 different colleges and 33 separate departments. The types of services and infrastructure provided by the IBEST cores are described more fully in their respective sections of this report.

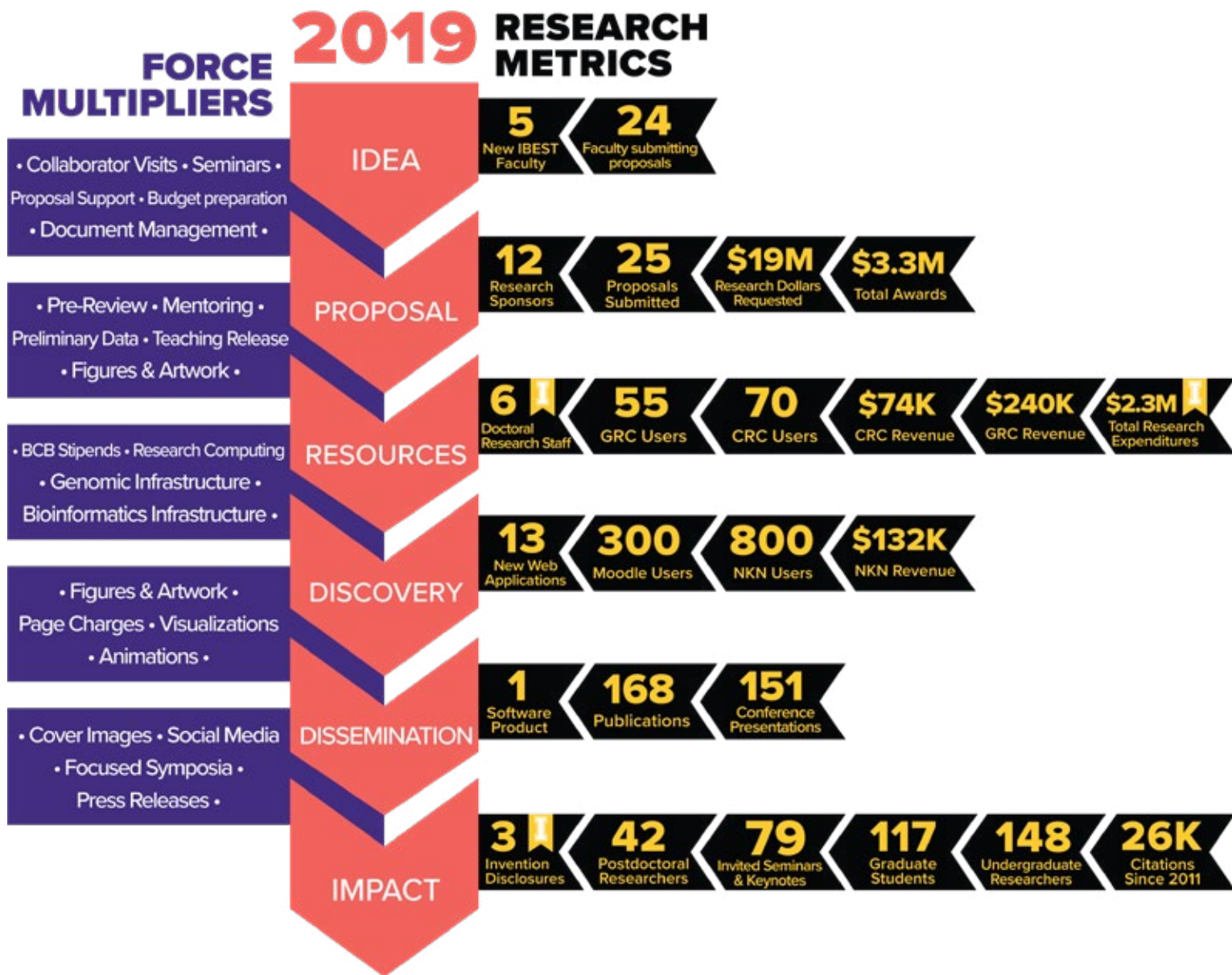
IBEST supports the research of **71 FACULTY** from across campus. This figure shows how these faculty engage in the different categories of IBEST's functions.



These heat maps describe how IBEST faculty, postdocs, and students are distributed across career stage and U of I's academic units, including **8 COLLEGES** and **33 DEPARTMENTS**.



2019 ACCOMPLISHMENTS & PERFORMANCE METRICS



LOGIC MODEL Each of the states in our model of the research process is associated with **METRICS**, variables that can be quantified and used to measure our progress toward our goals. Here, we define these metrics, describe our process for collection and measurement, and report them for Fiscal Year 2019. In some cases, our metrics do not align well with a fiscal year reporting window (publications in a calendar year being an obvious example). For these metrics, we report a “rolling window” to provide context for the 2019 partial calendar year.

In some cases, IBEST contributes directly to priority metrics that are used by the University of Idaho to measure progress in our 10-year Strategic Plan; these metrics are indicated with a gold ribbon.



IDEAS

2019 Accomplishments and Performance Metrics

IBEST plays an important role in helping researchers generate and refine their research ideas. We invest in activities such as IBEST lunch and our seminar series precisely because they help faculty discuss their research, identify future collaborators, and get critical feedback. As a Tier III Institute, IBEST seeks to have a campus-wide impact. Activities that help researchers generate and refine their ideas are also important in growing participation in IBEST across campus. Actual metrics related to research ideas aren't feasible, but research activity at this stage does scale with participation. We therefore track two metrics, the total number of faculty submitting proposals through IBEST and the number of faculty doing so for the first time.

24 NUMBER OF FACULTY SUBMITTING PROPOSALS THROUGH IBEST

While participation can be measured at any number of IBEST events (lunches, seminars, symposia, workshops), the number of faculty submitting proposals most closely aligns with the University of Idaho's goal of increasing research expenditures and achieving Carnegie R1 status.

NEW FACULTY SUBMITTING PROPOSALS THROUGH IBEST

IBEST seeks to broaden interdisciplinary research in evolutionary science. An important metric in this regard is the number of new investigators that submitted proposals through IBEST. In FY19, 5 new faculty chose to work with IBEST to submit proposals:

5

- ONESMO BALEMBA** | Biological Sciences CoS
- CHRIS HAMILTON** | Entomology, Plant Pathology & Nematology CALS
- ADAM JONES** | Biological Sciences CoS
- BRANT MILLER** | Curriculum & Instruction CEHHS
- MICHAEL OVERTON** | Politics & Philosophy CLASS



12
Research Sponsors

25
Proposals Submitted

\$19M
Research Dollars Requested

PROPOSALS

2019 Accomplishments and Performance Metrics

NEW PROPOSALS SUBMITTED IN FY19

PI	College/Department	Sponsor	Title	Amount	Status
Harmon, Luke	COS, Biology	National Science Foundation	NTR-HDR: DTN: Creating Tomorrow's Naturalists	\$2,949,956	Declined
		National Science Foundation	Dimensions US-South Africa	\$1,999,278	Declined
Jones, Adam	COS, Biology	National Science Foundation	Genomics of Sexual Selection in Pipefishes and Seahorses	\$1,028,242	Pending
Miller, Brant	CoED, Curriculum & Instruction	National Science Foundation	Methods and Coursework for Engaged Student Learning	\$299,923	Pending
Oswald, Benjamin	IBEST	National Science Foundation	CC*Compute: Machine Learning at the University of Idaho	\$393,693	Declined
Robison, Barrie	IBEST	National Science Foundation	The Evolutionary Arcade	\$2,641,821	Declined
Bruger, Eric	COS, Biology	BEACON	Evolutionary Interactions	\$13,949	Awarded
Top, Eva*	COS, BCB	BEACON	Genomic Islands and Pandemic Vibrio cholerae Evolution	\$18,201	Awarded
Jones, Adam*	COS, Biology	BEACON	Who adapts faster: sexual selection	\$90,281	Awarded
Parent, Christine*	COS	BEACON	Engaging Ecuadorian Educators in Evolutionary Ecosystems	\$24,332	Awarded
Rowley, Paul	COS, Biology	BEACON	Novel Killer Toxins and the Evolution of Fungicide Resistance	\$32,215	Awarded
		BEACON	Experimental evolution teaching	\$14,577	Awarded
Balemba, Onesmo	COS, Biology	National Institutes of Health	Diet-gut microbiota-host interactions	\$3,377,438	Declined
Mitchell, Diana	COS, Biology	National Institutes of Health	Macrophage Determinants of Retinal Regeneration	\$1,804,695	Pending
Robison, Barrie	IBEST	National Institutes of Health	EvoHealth: Improve pathways to STEM careers in Idaho	\$1,303,909	Pending
Hohenlohe, Paul*	COS, BCB	NIFA/USDA	Predicting Range Expansion in Diiorhabda	\$118,975	Pending
Soule, Terence	COE, CS	Michigan State University, NSF	Salmon Run	\$210,904	Pending
Overton, Michael	CLASS, Politics and Philosophy	Higher Education Research Council	The Date Revolution and Economic Growth in Idaho	\$1,954,025	Declined
Robison, Barrie	IBEST	Idaho State Board of Education	Darwin's Demons Mobile	\$74,700	Awarded
Top, Eva	COS, Biology	Idaho Department of Fish & Game	Diversity and evolution of Movi in sheep and goats	\$74,197	Awarded
Hunter, Sam	IBEST	Idaho Wheat Commission	Effects of the seed microbiome on amylase activity	\$28,274	Awarded
Parent, Christine*	COS, BCB	Society for the Study of Evolution	Education, Conservation, and Discovery of Biodiversity	\$1,000	Awarded
Tank, David C.	COS, Biology	Society of Systematic Biologists	Western Sword Fern and Predicting Cryptic Diversity	\$1,300	Awarded
		Society of Systematic Biologists	Pollination syndrome and dispersal in Lamourouxia	\$1,300	Awarded
Hamilton, Chris	COS, Entomology, Plant Pathology & Nematology	Google	Google AI Impact Challenge	\$529,586	Declined

*Proposal submitted by postdoc or graduate student

SUBMISSIONS: \$18,896,771

NEW AWARDS: \$374,326

PENDING: \$4,766,648

FY19 AWARD DISTRIBUTION

PI	College/Department	Sponsor	Title	Amount
Harmon, Luke	COS, Biology	National Science Foundation	Tree of Life	\$58,220
Nuismer, Scott	COS, Biology	National Science Foundation	Strenth of Coevolution	\$83,533
Sullivan, Jack	COS, Biology	National Science Foundation	Predicting Cryptic Diversity	\$185,429
Marx, Christopher	COS, Biology	National Science Foundation	Diverse Plant-Associated Community	\$1,777,711
Foster, James	COS, Biology	BEACON	UI Admin	\$65,731
Top, Eva	COS, Biology	National Institutes of Health	RO 1 Plasmid-Bacteria Coevolution	\$353,975
Forney, Larry J.	COS, Biology	University of Maryland, Baltimore	Multi-Omics Approach	\$67,755
		University of Maryland, Baltimore	Ecopathogenomics	\$28,365
Hohenlohe, Paul	COS, Biology	Washington State University	Infectious Cancer Transmission	\$148,141
Ridenhour, Ben	COS, Mathematics	Texas Biomedical Research Institute	Marmoset Nutrition and Dietary	\$159,675
Sheneman, Luke	NKN, IBEST	Department of Energy	DOE NEUP Biofuels Producing	\$74,000

FY19 AWARD DISTRIBUTION TOTAL: \$3,002,535

This table is not a comprehensive list of all the grants that IBEST manages.

RESOURCES

2019 Accomplishments and Performance Metrics

We quantify the research activity of IBEST using metrics that measure either research expenditures, numbers of research personnel, or usage of infrastructure.

\$3.4M **TOTAL AWARDS** We track both new awards that are administered by IBEST each fiscal year, as well as new increments to existing awards. IBEST PIs received 12 new awards in FY19, totaling \$374,326. Combined with existing grants, the FY19 total is \$3,376,861.

\$2.3M **RESEARCH EXPENDITURES** This metric, which is a priority metric for the University Strategic Plan, measures the dollars spent from sponsored grants and other activities related to research. In FY 19, IBEST research expenditures amounted to \$2,256,263.

6 **NUMBER OF DOCTORAL RESEARCH STAFF** This metric is also used in the University Strategic Plan and is part of the calculation for R1 status.

COMPUTATIONAL RESOURCES CORE USERS AND REVENUE

Usage of IBEST's research computing capabilities represents research activity that flows through IBEST and is related to institutional research expenditures.

70

\$74K

GENOMICS RESOURCES CORE USERS AND REVENUE

These metrics tell us the breadth of our impact and tracking revenue helps us move towards a sustainable business model.

55

\$240K

DISCOVERY

2019 Accomplishments and Performance Metrics

The process of discovery and data generation are difficult to quantify. However, modern science is often associated with Big Data. We have therefore begun to track data repositories and other metrics associated with NKN.

13 **WEB APPLICATIONS** NKN developed and deployed 13 new web applications in FY19. Notable applications include the [Idaho NSF EPSCoR GEM3](#) site, a re-design of the [Idaho Geological Survey](#) website, continued development on the [Climate Toolbox](#), and the NSF-funded [Deep Time Knowledge Base](#). With several of proposals and collaborations lined up in FY20, NKN will greatly expand its portfolio of data-driven research web applications.

300 **MOODLE ONLINE COURSES** NKN expanded their online digital course catalog in FY19 to reach over 300 active users in the Fire Science community via the Moodle learning management system hosted within the Fire Resource and Management Exchange System, [FRAMES](#). In FY20, NKN will expand their online course catalog by adding new users, developing new curricula, and diversifying their offerings.

800 **USERS AND REVENUE** Either through grants or our service center, NKN partners with diverse research teams to help them acquire, store, manage, and disseminate data as invaluable public research outputs. NKN leverages their growing data collection by developing interactive tools that help scientists and stakeholders discover, access, visualize, and analyze these data, whether on a [large scale](#) or on a [small scale](#).

\$132K

IN FY19, IBEST RESEARCH EXPENDITURES AMOUNTED TO **\$2,256,263**

AS OF FY19, IBEST AWARDS TOTAL **\$3,376,861**

DISSEMINATION

2019 Accomplishments and Performance Metrics

To help track the dissemination data of faculty participating in IBEST, we have partnered with the University of Idaho Library. The UI Library houses the VIVO database, which monitors publication indices and aggregates citations and other useful metadata.

168 PUBLICATIONS These are arguably the most important metric of scientific dissemination. Reporting publications on a fiscal year basis isn't particularly sensible, so we report a constantly updating set beginning with IBEST's formation as an Institute in 2011.

IBEST PUBLICATIONS

168 PUBLICATIONS IN 2019

Year	IBEST Publications	Total Citations	Average Citations
2011	83	5,236	63.1
2012	110	8,932	81.2
2013	91	3,922	43.1
2014	67	2,366	35.3
2015	107	2,466	23.0
2016	108	1,941	18.0
2017	107	1,182	11.0
2018	89	460	5.2
2019	168	200	1.2
Totals	930	26,705	28.7

CONFERENCE PRESENTATIONS

We track submitted conference presentations (poster or talk). These are self-reported in aggregate by faculty, and typically do not include student presentations.

151

SOFTWARE PRODUCTS

Many IBEST researchers are associated with computational disciplines. Thus, we have begun tracking software products. This year, IBEST researchers commercially released one piece of software – the evolutionary video game Project Hastur.

1

PROJECT HASTUR

Project Hastur is an evolutionary tower defense game, and the first implementation of Polymorphic Games' evolutionary procedural generation approach. Game enemies are encoded by a digital genome, and mutations of this genome variations are converted in the Unity Engine to different morphologies, behaviors, colors, and other game traits. Find more information about Project Hastur on page 45.



IMPACT

2019 Accomplishments and Performance Metrics

The most important component of the research process is also the most difficult to quantify. In fact, some research might not fully realize its impact until decades after it is first published (Mendel's work being a significant example). We can estimate impact using a variety of accepted but flawed metrics. These include citations, prestigious invitations to speak at conferences and institutions, and outcomes related to training. Training of undergraduates, graduate students, and postdocs is an important component of research in a University setting, one of the reasons these activities are classified as "broader impacts" by the National Science Foundation. We therefore report the numbers of these trainees that are mentored by faculty participating in IBEST.

26K CITATIONS Working with the UI Library, we have used the web of science database to quantify the total number of citations of publications that faculty self-report as associated with IBEST. We include only works published since 2011, the year IBEST became an Institute. This obviously omits the many publications associated with the COBRE grant that initiated IBEST. As of August 2019, IBEST publications had been cited 26,705 times. Four U of I faculty were recognized by Web of Science Group as Highly Cited Researchers in 2019. Three of these faculty are heavily involved with IBEST.

79 INVITED PRESENTATIONS An indication that researchers are considered thought leaders in their disciplines is invitations to speak at conferences, department seminars, or deliver keynote or other prestigious addresses. IBEST faculty report delivering 79 such presentations in FY19. The locations of the activities are represented on the map.

148
Undergraduate
Researchers

117
Graduate
Students

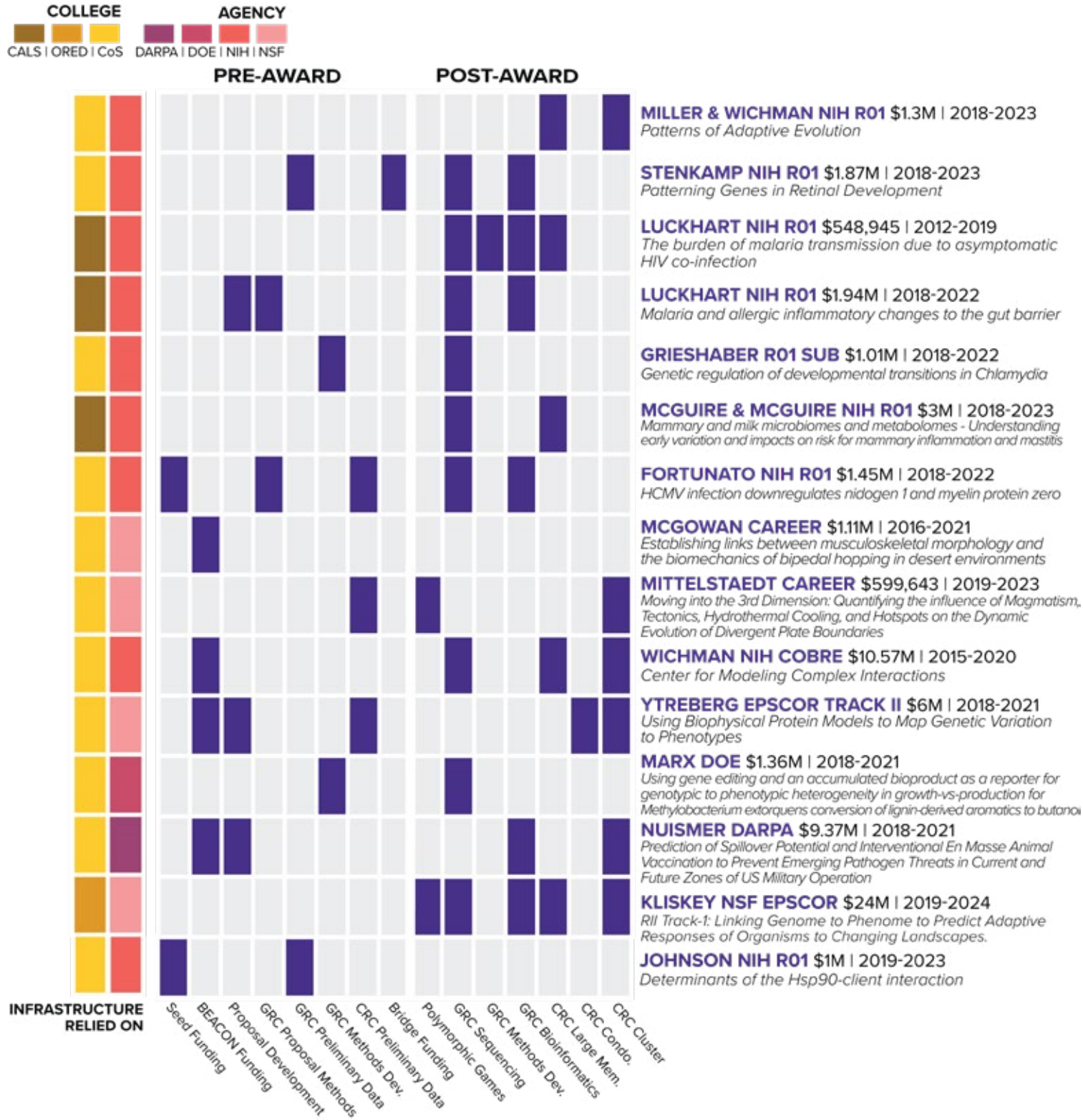
42
Postdoctoral
Researchers

3
Invention
Disclosures



NOTEWORTHY AWARDS ENABLED BY IBEST

Our metrics measure research that is administered by IBEST. However, these metrics fail to capture the research grants that rely on IBEST infrastructure but are not administered by IBEST. Significant current grants that fall into this category include:



The figure on page 27 explains each of IBEST's infrastructure components in more detail.

IBEST INFRASTRUCTURE

PRE-AWARD	POST-AWARD
SEED FUNDING IBEST has provided technology access grants and pilot grants to support the collection of preliminary data and proof-of-concept experiments.	GRC SEQUENCING As a service center, the GRC can generate genomic data for any UI faculty member.
BEACON FUNDING IBEST is part of the NSF Science and Technology Center for the Study of Evolution in Action (BEACON). BEACON has nucleated many new research projects at the UI.	CRC CLUSTER COMPUTING The CRC offers affordable high-performance cluster computing to UI faculty and students.
PROPOSAL DEVELOPMENT IBEST supports faculty in all phases of proposal development, as described on page 9.	GRC BIOINFORMATICS The GRC offers expertise in bioinformatics analysis of a variety of data types.
GRC PROPOSAL METHODS The Genomics Resources Core staff are available to write the methods sections for proposals that will use the GRC if funded.	CRC LARGE MEMORY SERVERS The CRC has several large memory servers appropriate for large scale bioinformatic analyses, including genotyping and genome assembly.
GRC PRELIMINARY DATA The Genomics Resources Core has been used to generate preliminary data to support grant proposals.	POLYMORPHIC GAMES UI faculty can collaborate with Polymorphic Games to create compelling visuals, animations, and digital outreach materials that feature their research.
GRC METHODS DEVELOPMENT The GRC staff work with PIs to develop innovative new methods for genomics data collection and bioinformatics.	GRC METHODS DEVELOPMENT The GRC staff work with PIs to develop innovative new methods for genomics data collection and bioinformatics.
CRC PRELIMINARY DATA The Computational Resources Core has been used to generate preliminary data to support grant proposals.	CRC CONDOMINIUM SERVICES Participants in the condo service of the CRC share unused computational capacity with the IBEST community, but their hardware is managed by the CRC.
BRIDGE FUNDING IBEST has offered bridge funding to support PIs during gap years between grants.	

\$65M
 in active UI awards rely on IBEST investments and infrastructure

2019 EVENTS

THANK YOU
— FOR HELPING US PLAN —
IBEST'S FUTURE

IBEST *Charrette & Reception*

On September 21, 2018, IBEST hosted its Charrette and Reception. Charrettes are intense periods of collaborative design activity that originated in the architecture and design disciplines. We modified the Charrette process to identify how IBEST can most effectively support the research endeavors of participating faculty. Approximately 60 participants worked in small breakout groups during the event. Each group generated a chart that depicts their vision of IBEST over the next 10 years. Participants then viewed and discussed the results from all the groups. Ultimately, IBEST will use the ideas from the Charrette to prioritize investments, identify grant opportunities, and develop program-scale proposals.

In March and April, the College of Science, Department of Mathematics, and IBEST sponsored the University of Idaho Student Data Science Competition. The goal was to promote Data Science research and education on campus. The competition had two tracks: The Data Analytics competition asked participants to develop a predictive model of *University Enrollment and Retention* based on a given dataset that the CRC and GRC put together; The Data Visualization track asked participants to explore any dataset of their choice and describe what they learned in a compelling visual manner.

DATA
SCIENCE
COMPETITION



On May 15 and 16, 2019, IBEST hosted the UI Research Computing and Data Science Symposium. This event included workshops, a poster session, and a variety of speakers, including keynote speaker Josh Hartung, founder of PolySync. Participants learned and spoke about things such as autonomous cars, microbes, fever epidemics, data literacy, and IBEST core facilities.



On September 21, 2018, IBEST hosted the 15th annual IBEST Science Expo. Almost 50 participants presented research posters in focus areas including evolutionary science, research computing, genomics, and bioinformatics. In addition to learning from the poster presentations, attendees explored interactive research animations and virtual reality demonstrations.

SKETCH YOUR Science

On March 21, 2019, IBEST hosted its first-ever Sketch Your Science, an event that paired scientists together with artists to create a new interpretation of their research. Participants spent the evening partnered with local traditional, digital, and 3D artists who used their creative arsenal to provide uniquely compelling visualizations of research hypotheses, approaches, and data. The most creative and informative pieces were highlighted throughout the evening, and attendees explored all of the visualizations at the end of the reception.



CRC

COMPUTATIONAL RESOURCES CORE

MISSION & VISION

The mission of the CRC is to provide state of the art computing and data management services to our customers. Our vision is to remain technologically current in hardware, software, and services while partnering with customers to help them perform and disseminate their research in a fiscally sustainable way. Our guiding principles are to maximize the reliability, availability, and effectiveness of our services while minimizing administrative costs.

INFRASTRUCTURE

HIGH PERFORMANCE COMPUTING

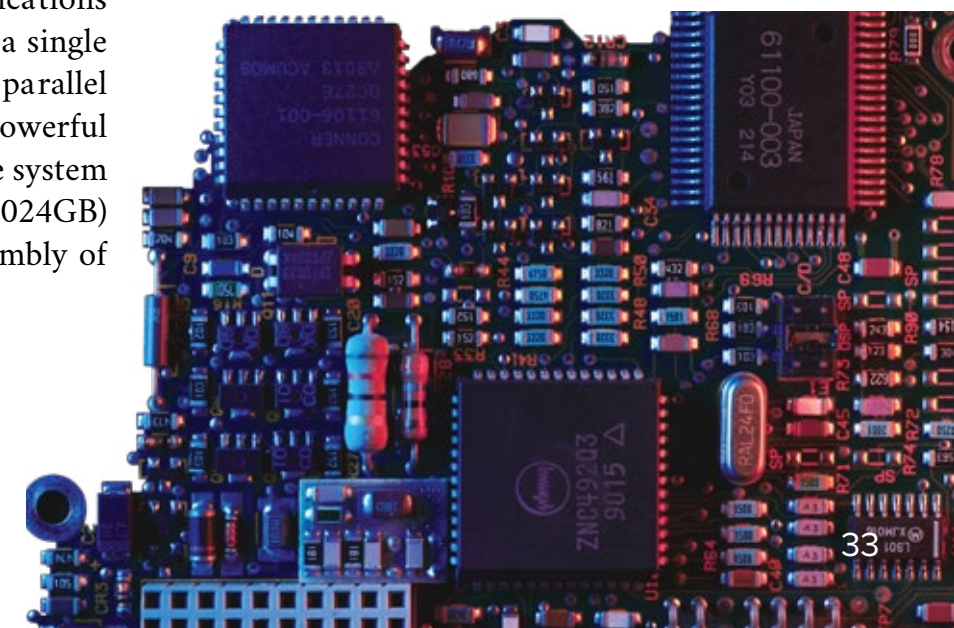
CRC has one main compute cluster for research and genomic data analyses. We have continued to add computational capacity, the main cluster now provides 2080 processor cores (up from 1592 processor cores last year) and over 11 terabytes of system memory. This year we have continued to see increased demand for GPU enabled computational infrastructure to be used for machine learning and neural network simulation. Four of the new compute nodes have modern GPU to make GPU accelerated computing accessible to all our users. Cluster nodes are connected with 40Gb/s QDR Infiniband connections, providing fast, low latency data transmission for increased performance of HPC applications. We also added an additional 'standalone' server, for a total of twelve servers (over 600 total cores and over 5 terabytes total system memory) for applications that require large amounts of memory on a single system but do not take advantage of the parallel cluster resources. Three of our most powerful servers in this group contain 256 times the system memory of a standard desktop (1TB or 1024GB) and are used primarily for sequence assembly of next-generation sequencing data.

DATA STORAGE

The CRC maintains two tiers of primary storage. The first tier is comprised of fast but more expensive disk arrays, which we have expanded to 260TB. The second tier uses the Ceph open source software and has 30 servers and nearly 2 PB of hard drives. The Ceph system provides greater performance and has better self-balancing and healing properties. Additionally, we have more than 300TB disk available for data archiving and backup storage within the McClure data center. We backup regularly to servers located in the UI Library datacenter. In addition, the core provides in-house developed solutions to maintain data integrity and restoration.

Dr. Benjamin Oswald
CRC Director

"High Performance Computing for Everyone"



GRC

GENOMICS RESOURCES CORE



Dr. Sam Hunter
GRC Director

“An Innovative Approach to Genomics Research”

MISSION

The mission of the IBEST Genomics Resources Core (GRC) is to provide researchers at the University of Idaho access to cutting edge genomics technology and the bioinformatics tools needed to acquire, analyze, and visualize data.

VISION

The vision of the GRC is to stay current in genomics technology and bioinformatics, remaining agile with respect to new techniques and approaches, and to build partnerships with research groups and other regional core facilities.

COLLABORATIVE RESEARCH SUPPORT

The IBEST GRC is the only comprehensive facility on the University of Idaho campus that houses all the equipment and personnel necessary to aid researchers in every aspect of high-throughput genomics research. It provides the molecular expertise and equipment needed for most high-throughput sequencing studies, and develops partnerships with other service facilities when additional capacity or other specialized equipment are warranted.

The real benefit of the IBEST Genomics Resources Core facility, however, has been the integration of bioinformatics data analysis with data generation. The GRC maintains a strong partnership with the University of Idaho IBEST Computational Resources Core facility. This tight integration between the GRC and CRC has numerous advantages. First, the CRC provides the storage and computational power necessary for the analysis of the large-scale genomic data sets that are produced by the GRC. Second, the collaboration between the cores provides a great deal of agility with regard to the development of new bioinformatics techniques and analyses.

This fosters innovation and creative activity that are the hallmark of IBEST, and differentiates the GRC from other more “traditional” genomics core facilities around the US and the world.

The GRC offers consultation on experimental design, appropriate and best use of technologies, and bioinformatics support to perform analysis, quality assurance, interpretation, and visualization. Through a unique strategy known as “the triangle of collaboration,” an investigator, molecular scientist, and bioinformatician meet regularly as a team to discuss the goals and objectives for a project. This strategy helps improve the success rate of GRC projects, and reduces costs by generating informative data on the first attempt for a given experiment.



GRC DNA SEQUENCING LABORATORY

DNA sequencing has become an indispensable tool for basic biological research, biomedical research, diagnostics, and molecular systematics. Current applications using DNA sequencing include whole genome shotgun sequencing for alignment or de novo assembly of previously unknown genomes, transcriptome sequencing, targeted re-sequencing, rapid/speed-congenics, transposable element enrichment, single nucleotide polymorphism discovery, metagenomics and amplicon sequencing for studies on microbial community composition, and many more. The GRC also has equipment and robotics for high throughput sample preparation associated with activities upstream of DNA sequencing, such as library preparation, including an elegant DNA-normalization technique. This equipment enables researchers to streamline sample preparation, thereby reducing the costs of operating the core. Presently, the core has the following equipment in its DNA Sequencing Laboratory:

DNA Sequencing

- » Pacific BioSciences Sequel II
- » Illumina MiSeq Sequencing Platform
- » Illumina HiSeq Sequencing Service
- » Oxford Nanopore Sequencing Platform

Library Qualification & Quantification

- » Life Technologies StepOnePlus
- » Advanced Analytical Technologies Fragment Analyzer
- » Agilent 2100 Bioanalyzer

Library Preparation and Size Selection

- » Fluidigm Juno
- » Fluidigm Access Array
- » Wafergen Apollo 324
- » Sage Biosciences BluePippin
- » Covaris M220
- » Coastal Genomics Light Bench

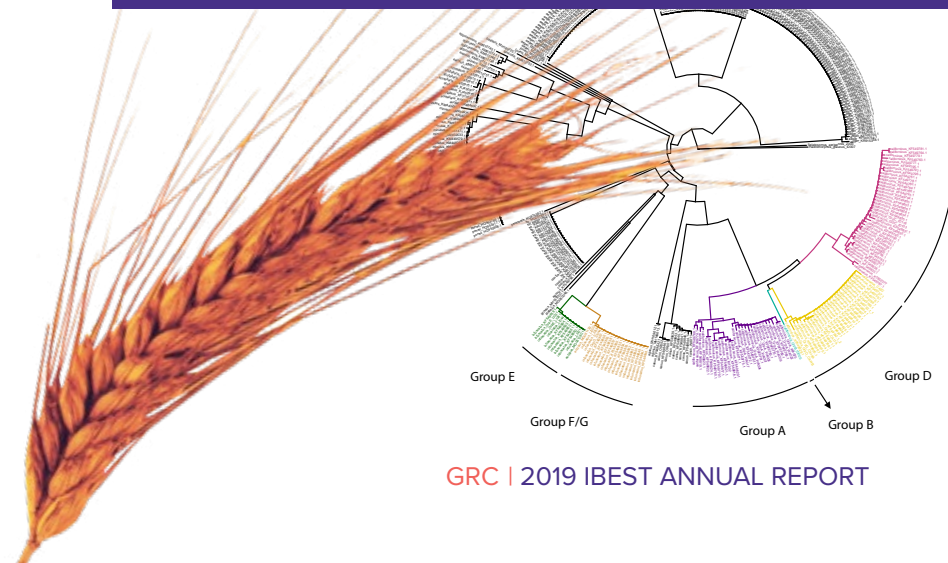
Sample Quantification

- » Molecular Devices Plate-Reader and
- » Invitrogen Qubit 3.0

GRC USER CORE The GRC also maintains equipment that is accessible to faculty, staff and students of University of Idaho. This equipment is primarily designated for high throughput sample preparation and quality assurance. Users are trained by GRC laboratory staff before using the equipment and are responsible for any reagents needed to run their samples. Equipment in the GRC User Core used for high sample throughput and quality assurance include:

- » DNA, RNA, and Library Qualification
- » Qiagen Tissuelyser II and QIAxcel
- » Molecular Devices SpectraMax Paradigm
- » Support Equipment for DNA & RNA Purification
- » Thermo Scientific KingFisher Flex
- » Boreal Genomics Aurora
- » Diagenode Bioruptor Plus (UCD-300)
- » ABI 9700
- » Support Equipment for DNA & RNA Purification
- » Qubit 2.0 Fluorometer

In collaboration with researchers from multiple institutions and organizations, the GRC investigated the population genomics and phylogenetics of **wireworm**, an Idaho agricultural pest. Genomic data from hundreds of wireworms was generated and analyzed, and six divergent groups were identified across the Pacific Northwest. This information will help guide effective wireworm management strategies.



PROJECT CONSULTATION Core facility staff consult with investigators to discuss project aims, expectations, experimental design, appropriate and best use of technology, sample quantity and quality issues, and data analysis needs. During consultation, a project timeline is formed, expected costs are discussed, deliverables are identified, and a user agreement is reviewed. Having these discussions early in a project provides an opportunity for Core personnel to offer their expertise, advice, and assistance to enhance the proposed project and sidestep common and nuanced problems. This service is especially important to researchers developing grant proposals, where a detailed quote and sophisticated understanding of the protocols and analysis are likely to increase chances for funding and ensure accurate budgeting.

PROJECT MANAGEMENT The Genomics Resources Core offers genomics project management to customers by integrating services in all three phases of genomics research: project planning and consultation, genomic data generation, and bioinformatics data analysis. In contrast, most core facilities around the country focus mainly on data generation, leaving investigators to struggle with immense data sets with little help. Our integrated approach is very unusual, and a key component to our continued success.

GENOMICS DATA GENERATION The GRC operates and maintains equipment (described above) that allows high throughput sample preparation, quality assurance, and generation of high throughput DNA/RNA sequence data. When projects require technologies that are not present in the facility, the GRC facilitates access to the technology through cooperation and collaboration with other regional core facilities. For example, when investigators require the additional capacity provided by the Illumina HiSeq platform, the GRC staff prepares Illumina libraries that are sent to other institutions for sequencing (such as University of California Berkeley or the University of Oregon), and the data are then sent back to the GRC for processing and analysis. Doing the sequencing "off-site" is seamless and causes no additional work for the investigator.

BIOINFORMATICS AND DATA ANALYSIS

Bioinformatics data analysis is often the most challenging aspect of any experiment, and until very recently was often overlooked in budgeting for experiments. The GRC offers bioinformatics services through staff bioinformaticians and can perform a full range of analytic tasks to address questions in areas such as population genomics, microbial community dynamics, differential gene expression, functional and comparative genomics, and systems biology. GRC bioinformaticians begin with raw output from genomics equipment and proceed through quality assurance, data processing and analysis, data interpretation, and visualization. Analyses are conducted using pipelines in the public domain or those developed by Core staff members. Core personnel have developed analytical techniques and pipelines for microbial community analysis, genome assembly, transcriptome assembly, population variant analysis, phylogenetic analysis, SNP/INDEL detection, and RNAseq analysis. These pipelines transform and manipulate raw data into a form and format that can be mined by investigators.

The GRC bioinformaticians seek feedback from investigators after preliminary data analysis, so that adjustments in output content, form, and format can be made. Data are then re-analyzed or additional analyses are performed until the project's goals are met, figures are generated, and summary tables are provided to the investigators in a form that is useful to them. The Core staff provides investigators with detailed knowledge of the laboratory protocols and bioinformatics methods used so they can be included in reports and publications as needed. As a result, core staff members are often included as co-authors on publications because of their significant intellectual contributions to research projects.

NKN

NORTHWEST KNOWLEDGE NETWORK



Dr. Luke Sheneman
NKN Director

“NKN Enables Data-Intensive Science”

MISSION

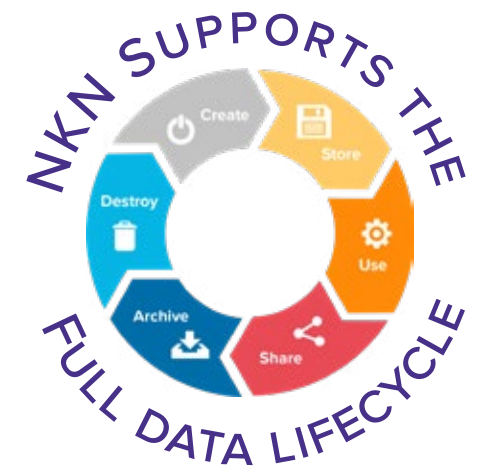
Accelerate the transformation of research data into knowledge by making transdisciplinary research data findable, accessible, interoperable, and reusable (FAIR) by supporting full end-to-end Data Lifecycle Management. Combine flexible computing infrastructure with exceptional technical expertise to design and deploy software tools for interactive data access, analysis, mapping and visualization.

VISION

Accelerate the pace of scientific discovery by becoming a leading interactive Data Observatory, enabling seamless access to vast, interoperable, and transdisciplinary research data.

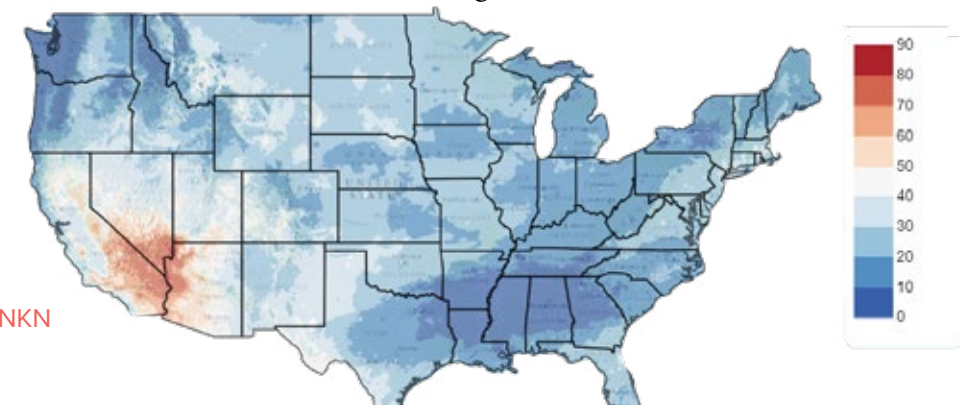
INFRASTRUCTURE

NKN manages cyberinfrastructure in Moscow and the Idaho National Laboratory (INL) Collaborative Computing Center (C3) in Idaho Falls. These two facilities are connected through the Idaho Regional Optical Network (IRON). NKN manages more than a petabyte (PB) of research data storage between UI and INL. Both installations use a flexible virtualized architecture that allows researchers to manage their own servers to meet their project needs without having to purchase, deploy, and manage their own physical hardware. NKN currently manages over 100 virtual machines (VMs) installed with Red Hat Enterprise Linux 6/7, CentOS 7, or Windows Server operating systems. This infrastructure supports a rich ecosystem of integrated software services and layers including databases, Esri geospatial servers, computational modeling servers, collaborative cloud-based data sharing, data-driven web applications, and more.



OPPORTUNITIES

In 2019, the Northwest Knowledge Network (NKN) merged with IBEST to become a third core facility within the Institute. By joining forces with IBEST, we are better positioned to collaborate and share resources, ideas, and personnel in a way that extends our mutual reach and impact to the overall UI Research Enterprise. NKN and the CRC are now materially connected in a number of mutually beneficial ways, including sharing our new Systems Administrator (Jim O’Dell), facilitating high-performance network connections between campus data centers, transferring hardware between NKN and the CRC, collaborating on projects, and referring projects and partners to each other. We look forward to identifying and pursuing new opportunities for integration and collaboration in the coming year.



OUTREACH

NKN was involved in a number of important drone-related outreach activities in FY19, including:

- » Developing and leading STEM workshops on drone piloting and navigation through Upward Bound/TRIO for dozens of high school students
- » Co-sponsoring and co-leading the Fall 2018 UI Drone Summit
- » Co-founding the UI Drone Lab
- » Developing and deploying the UI Drone Lab website (uidronelab.org)
- » Teaching a Drone Workshop at the at the 90th Annual Meeting of the Northwest Scientific Association (NWSA)
- » Piloting drones for 2019 Spring Commencement for UI Marketing and Communications.

In addition, NKN performed a number of other outreach activities including:

- » Participating in and hosting statewide C3+3 meetings centered on coordinating Research Computing throughout Idaho.
- » Developing and deploying the 2019 Spring Data Science Competition Website.
- » Participated in the 2019 IBEST Research Computing and Data Science Symposium.

FUTURE DIRECTIONS

EXTERNAL FUNDING NKN is actively involved in a number of proposal-writing efforts centered around building Research Computing and Data Science capacity at the University of Idaho. Our largest current proposal writing activity aims to establish a new Data Science Core Facility at the UI by expanding existing capabilities within NKN and partnering with synergistic groups. The end goal is to establish a critical mass of Data Science infrastructure and expertise that will enable and accelerate data-intensive science at UI.

MOBILE APPLICATIONS NKN now has experience developing Mobile applications for iOS and Android that rely on web service APIs to communicate to back-end servers and databases. We anticipate a growing demand for Mobile Application development services at NKN, and we have partnered with UI ITS to deploy these tools on the Apple App and Google Play stores, under the University of Idaho branded storefronts.

END-TO-END RESEARCH DATA FLOWS NKN's expertise in developing backend database systems and APIs, combined with our ability to develop interactive web/mobile front-end interfaces, is creating an increase in researcher requests for us to develop digital tools that rely on more complex, bi-directional data transactions. These include mobile Citizen Science or Decision Support tools that interact with backend databases and computational models. To the extent that NKN demonstrates competency in this area, we expect this to be a rapidly growing area of our future effort.



Jennifer Hinds collects remote sensing imagery for a study of differential herbicide treatment regimens on experimental crops at UI Parker and Kambitsch Farms.

SERVICES

The NKN Service Center provides a number of services to support data-intensive research at the University of Idaho. These services include access to robust research-oriented compute and data storage infrastructure as well as hourly services to develop research software systems including web and mobile applications. NKN also provides expert technical consulting services for developing data management plans, providing IT consulting and systems administration, and more. With its growing UAS Data Acquisition program that includes two FAA Part-107 certified drone pilots and a small fleet of light-duty production drones, NKN also designs and pilots research-oriented drone missions that result in processed, value-added remotely sensed data products.

NKN developed, launched, or redesigned

13

new interactive, data-driven, research-oriented web applications in FY19



NKN provides online courses through Moodle with over 300 active users



NKN has

800

active user accounts from all over the world

PROJECT HIGHLIGHT

Idaho NSF EPSCoR Genes by Environment, Modeling, Mechanisms, and Mapping (GEM3) is a statewide NSF EPSCoR program that combines research strengths in genomics, complex modeling, and geospatial analysis to advance one of the most compelling and contemporary national challenges of our time: the adaptive capacity of species to cope with a changing climate. Such complex issues

require a diverse expertise, and GEM3 supports researchers from Boise State University, Idaho State University, and the University of Idaho. However, maintaining meaningful and productive connections between individuals in different disciplines across a state with the geography of Idaho presented a unique set of challenges. To support this collaborative venture, NKN was enlisted to produce innovative online tools to help people across the state to learn, share, and communicate.

Leveraging our experience with past multi-discipline and multi-institutional programs, we set out to create a collaborative platform that went beyond an informational website. The GEM3 Collaborative Hub links GEM3 team members to their research activities in working groups, publications, and dataset contributions. Anyone GEM3 participant can log in, share an event, or create a working group and contribute to the growing body of knowledge that is GEM3. This digital platform provides the foundation to help grasp the interconnected nature of Idaho science with the goal of enabling important collaborations. The GEM3 Collaborative Hub can be found at idahogem3.org

POLYMORPHIC GAMES



EVOLUTION ALWAYS WINS

MISSION & VISION

Polymorphic Games is an experimental video game development studio. Our studio employs interdisciplinary teams of undergraduate students to create compelling and fun video games that are based on scientific models.

PUBLISHED GAMES



DARWIN'S DEMONS

Polymorphic Games' first project was *Darwin's Demons*, a "space shooter" game inspired by *Space Invaders*. In *Darwin's Demons*, the player battles an evolving population of aliens. The aliens' traits are encoded by a digital genome and the fittest enemies reproduce to create the next generation causing the population to adapt to the player. The name of the game was inspired by the Darwinian Demon metaphor, which describes an organism that can evolve without constraint. In *Darwin's Demons*, each trait can evolve independently (there are no evolutionary trade-offs), meaning that eventually the player will lose. The player's objective is to beat the high score. Players can choose from a wide range of ships and secondary equipment, which increases player interest and serves to drive evolution along different trajectories. Development on *Darwin's Demons* began in May 2016, and the game was released for sale on Valve's Steam platform on February 13, 2017 (the Monday after Darwin Day). To our knowledge, *Darwin's Demons* was the first commercially released game to fully feature evolving enemies.

PROJECT HASTUR

Polymorphic Games' second commercial release was *Project Hastur*, an evolutionary tower defense game. *Project Hastur* features fully realized 3D game environments and enemies. As with *Darwin's Demons*, all of the game enemies are encoded by a digital genome, and mutations of this genome can produce a startling array of phenotypes. In *Project Hastur*, the player can play through a campaign that features 14 unique maps that unlock a series of defensive capabilities. The game features its own story, a wide variety of upgrade choices, and many fun "Easter Eggs" about evolution.



For *Project Hastur*, our student developers created a method for evolutionary procedural generation of game enemies. All of the creatures in the game have the same architecture of their digital genomes (62 genes encoded by real numbers). These genomes are converted in the Unity Engine to different morphologies, behaviors, colors, and other game traits. This technique evolves original game content as the game progresses rather than relying on pre-programmed scripts—an innovative programming approach developed by Polymorphic Games.



DARWIN'S DEMONS
AND
PROJECT HASTUR
ARE ON STEAM



OUTREACH

STEM EDUCATION We were motivated to create Polymorphic Games by the idea that evolution makes a game better – more compelling and more fun – because the game adapts to the player. This approach represents a positive combination of STEM engagement and informal learning. Given a compelling game, players are inherently motivated to learn the underlying evolutionary concepts in order to succeed at the game objectives. Thus, the goal of Polymorphic Games is to make fun and compelling games, and to use established tools (e.g. in-game achievements, Easter eggs, challenges, and missions) to increase the games' educational impact.

Project Hastur and Darwin's Demons both feature **EXPERIMENT MODE**, in which the evolutionary parameters can be altered. This feature has numerous benefits – it allows exploration of the evolutionary system on which the game is built and allows the player to autonomously test “cause and effect” as they adjust parameters.



COMPLETED GRANTS

\$332,277

6 grants from 2016-2018 NSF BEACON, IGEM, UI ORED, & Vandal Ideas Program

VIRTUAL INFLUENZA Our students also developed a virtual reality influenza simulation in which the user uses colored antibodies to defend an epithelial cell wall from invading influenza virus. In our prototype, the participant can see and manipulate 3D versions of the influenza models from the NIH 3D print exchange, including models of the viral particle, and different forms of the Hemagglutinin molecule. At the beginning the antibodies are color matched to the virus. After one minute, we change flu season. The viruses now have a different color of Hemagglutinin and the antibodies cannot bind to the new Hemagglutinin antigen (they bounce off). The participant can vaccinate themselves with a button, changing the color of their antibodies and allowing them to effectively avoid infection.



UNDERGRADUATE TRAINING

INTERDISCIPLINARY ENVIRONMENT – COLLABORATION, COMMUNICATION, LEADERSHIP Polymorphic Games employs a unique development approach, in which undergraduates from a wide range of disciplines (including Computer Science, Virtual Technology and Design, Biology, English, Theater, Education, Business, and Music) collaborate to create video games that incorporate evolution as a core game mechanic.

CURRENT PROJECT

DARWIN'S DEMONS MOBILE

The new version of *Darwin's Demons* will bring evolutionary procedural content generation into the world of mobile gaming. As with our previous games, *Darwin's Demons Mobile* will use evolutionary models to evolve original game content as the game progresses rather than relying on pre-programmed content. Bringing this new type of game into the mobile market creates a unique and replayable mobile gaming experience, as well as an opportunity for Polymorphic Games to expand its market reach and continue to move towards becoming a self-supporting company.

The team of students currently working on the *Darwin's Demons Mobile* game come from a wide range of academic programs. Lily Mason and Graeme Holliday, both Computer Science majors, are the game's programmers; Parker Piedmont, a Computer Engineering and Music double major is composing the music for the game; Aaron Yama, a Virtual Technology and Design major, is one of the game's artists, and Savanna Estey, a Journalism and Mass Media major, is the project's Social Media Coordinator.

Polymorphic Games is on track to have released three commercial games, *Darwin's Demons*, *Project Hastur*, and *Darwin's Demons Mobile*, in four years. A nearly unprecedented feat in an industry where most indie development efforts fail to get even one game to market.





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