



## **MT-EPSCoR/Montana Institute on Ecosystems: Integrative Goals, Objectives and Activities Plan**

**Updated June 2016**

The **mission of the MT-EPSCoR INSTEP III program** is to advance Montana's research and engineering capacity with a focus on:

- 1) Providing understanding of ecosystem dynamics in the face of regional climate change
- 2) Assessing the consequences of ecosystem change on the environment, communities, and economic vitality in Montana
- 3) Providing knowledge and tools to educate and engage the people of Montana to adapt to the changes

As a component of this program, MT-EPSCoR has helped to establish the Montana Institute on Ecosystems (IoE) to develop a statewide network to implement integrated project components. Our intent is for the IoE to become a self-sustaining institute beyond EPSCoR support. This close relationship is designed to ensure successful implementation and create a lasting impact from NSF EPSCoR RII investments.

MT-EPSCoR works closely with the Montana Science & Technology (MTSC) Board and the Office of the Commissioner of Higher Education (OCHE) Research Director.

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Montana Science and Technology Plan (updated 2015):  
Montana: [http://mus.edu/research/MUS\\_STPlan\\_2015.pdf](http://mus.edu/research/MUS_STPlan_2015.pdf)

**The Montana Institute on Ecosystems (IoE)** is a community of scholars and partners with a shared vision to advance integrated environmental sciences and related fields. The IoE draws on the extraordinary landscapes of Montana and beyond to understand complex ecosystems including the interconnectedness of people and nature. The IoE has operational hubs and co-directors at Montana State University and The University of Montana.

MSU IoE Director: Dr. Cathy Whitlock  
UM IoE Director: Dr. Maury Valett  
[www.montanaioe.org](http://www.montanaioe.org)



## Goals Overview:

### RESEARCH

- Goal 1.** Investigate dynamics and vulnerabilities of Mountain and High Plains ecosystems through a portfolio of multi-scale research projects (*Focus Areas 1, 2, and 3; Fig. 1*)
- Goal 2.** Ensure integrated research and outreach results across institutions and disciplines in ways that build permanent interdisciplinary capacity (*Integration; Fig. 2*)
- Goal 3.** Ensure integration of social-ecological systems inquiry in the total portfolio of research capacity in this RII project and its key infrastructure effort, the Montana Institute on Ecosystems (IoE), to better understand ecosystems undergoing rapid change (*Social-Ecological Systems Initiative; Fig. 1*)

### HUMAN RESOURCE INFRASTRUCTURE

- Goal 4.** Educate and train the next generation of professionals in emerging ecosystem sciences, including those pertaining to social-ecological systems (*Education*)
- Goal 5.** Expand and coordinate opportunities for knowledge dissemination and training to improve STEM workforce development (*Workforce*)
- Goal 6.** Engage the full diversity of Montana's human and institutional resources in the achievement of the RII project goals and objectives (*Diversity*)

### CYBERINFRASTRUCTURE

- Goal 7.** Implement new and integrate existing *cyberinfrastructure* to improve statewide (1) collaboration and communication, (2) education and outreach, and (3) research computing resources that foster integrated outcomes and increase competitiveness in ecosystem sciences (*Cyberinfrastructure*)

### OUTREACH

- Goal 8.** Create and maintain a science outreach network that increases the visibility of MT-EPSCoR and the IoE and engages IoE integrated science teams, Focus Area project outcomes, and statewide vulnerability to climate change assessment with stakeholders, focusing on resource managers, decision-makers, STEM educators, and the general public (*Outreach*)

### MANAGEMENT AND EVALUATION

- Goal 9.** Develop the IoE as a collaborative structure and resource to improve statewide research, education, and science engagement capacity and competitiveness in interdisciplinary ecosystem and social-ecological system sciences (*Collaborative Management*)
- Goal 10.** Implement an integrated internal assessment and external evaluation program that allows for continual evolution, improvement and fine-tuning of the MT-EPSCoR programs and activities (*Assessment*)

### PROJECT SUSTAINABILITY

- Goal 11.** Establish the IoE as a lasting statewide research, education, and outreach infrastructure (*Sustainability*)

## Detailed Goals, Objectives, Outcomes, and Implementation Strategies:

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### **Goal 1. Investigate dynamics and vulnerabilities of Mountain and High Plains ecosystems through a portfolio of multi-scale research projects (*Focus Areas 1, 2, and 3; see Figure 1*)**

**Research co-Leads:** Maury Valett, UM IoE co-Director and Cathy Whitlock, MSU IoE co-Director

#### **Targeted Outcomes:**

- A new operational model for creating and maintaining interdisciplinary ecosystem science across the institutions within the Montana University System and Montana’s tribal colleges.
- A portfolio of research initiatives that range from understanding microbial processes to landscape-level patterns in Montana’s benchmark ecosystems
- Increased collaborative capacity within Montana to undertake interdisciplinary research focused on the ecological consequences of climate change.
- Science-management partnerships that support interdisciplinary vulnerability assessments.

#### **Overall Research Context:**

A grand challenge in ecosystem sciences is to understand the physical and biotic processes that govern ecosystem structure and function and how these interactions are directly and indirectly influenced by climate change. The MT-EPSCoR program is bridging three scientific fields—microbial ecology, systems ecology, and climatology — by assembling interdisciplinary teams to investigate the dynamics of, and linkages among, multi-scale processes that govern ecosystem responses to climate change (Figure 1). Understanding the impacts of climate change requires integration of multi-scale studies and development and testing of models that link climate, hydrologic cycling, and bio-energetic balances from microbial to landscape scales to explain ecosystem structure and processes. In the big picture, climate change will alter how hydrology, energy balance, and ecosystem composition and structure combine to influence local and large-scale controls. Looking at how these changes will impact Montana’s ecosystems provides an integrating theme.

#### **Research Objectives**

- 1.1 Use Montana’s benchmark ecosystems (i.e., large landscapes) as natural laboratories for ecosystem science.
- 1.2 Develop a portfolio of new and existing research projects that engage multiple institutions and researchers in interdisciplinary investigations of Montana’s benchmark ecosystems, from microbial process to landscape pattern, to better understand the region’s vulnerability to climate change.
- 1.3 Explore new modeling approaches and simulations relevant to studying key ecosystem processes and connections.
- 1.4 Examine the scalability of processes from local-scale and short-term to regional-scale and long-term for understanding of climate and ecosystem change across spatial and temporal scales.
- 1.5 Address both natural and social-ecological factors that have contrasting biophysical contexts and span different spatial, temporal, and organizational scales to better understand large ecosystem dynamics.

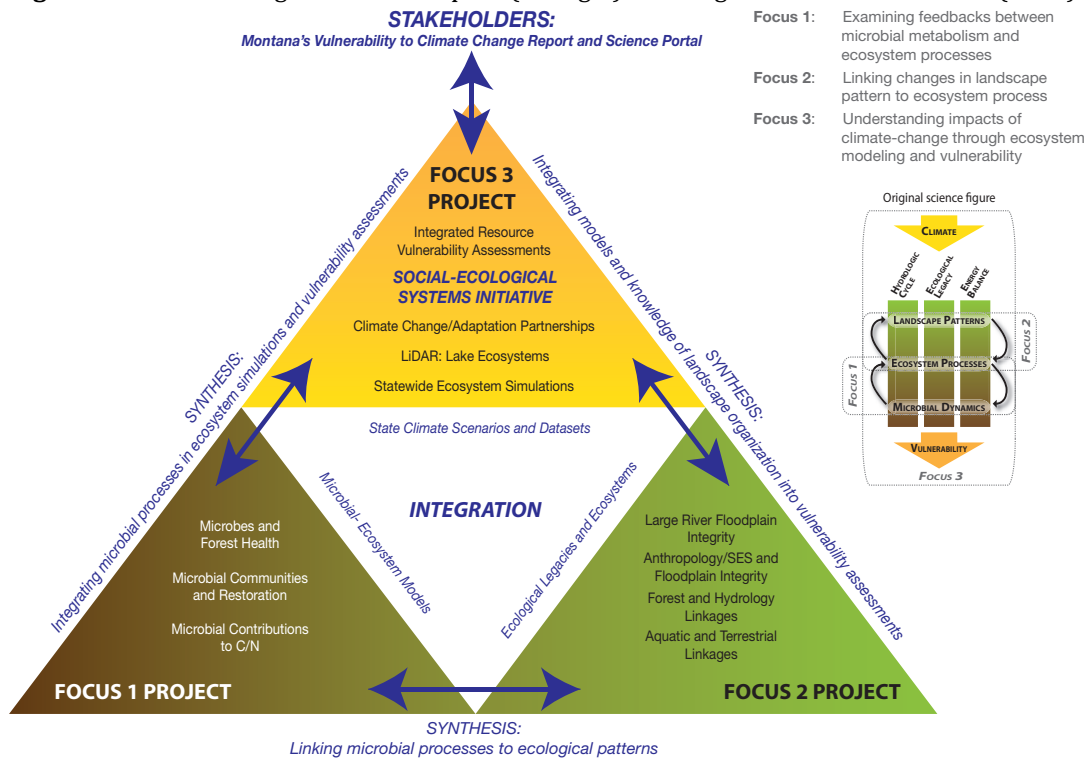
#### **Implementation and Integration Actions**

- Assemble science teams from across the Montana University System, Montana tribal colleges, state and federal agencies, non-profit organizations, and the private sector to build interdisciplinary research collaborations.
- Establish a nationally-novel and new statewide Institute on Ecosystems to promote, facilitate, and coordinate the MT-EPSCoR RII Track 1 research activities.

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- Identify and provide seed support for candidate research projects for inclusion in research portfolio, based on their potential for solution, generalization, cross-problem and cross-institutional integration.
- Seek feedback from MT-EPSCoR External Advisory Board and external reviewers on the research portfolio and outcomes.
- Initiate searches for graduate students, postdoctoral researchers, and new faculty to fill gaps and enhance existing expertise

**Figure 1:** Revised integrated science plan (triangle) and original science schematic (inset).



## Goal 2. Increase integrated research and results across institutions and disciplines in ways that build permanent interdisciplinary research capacity (*Integration*)

**Integration Lead:** Cathy Whitlock, MSU IoE co-Director

### Targeted Outcomes:

- Highly integrated, inter-institutional collaborations developed to tackle necessary complex interdisciplinary ecosystem science initiatives.
- Retention and promotion of new faculty in interdisciplinary fields in ecosystems science across the MUS with specific and strategic institutional structures and mentoring networks.
- Broad engagement and communication with all of Montana's institutions of higher education on topics related to ecosystems sciences, social-ecological systems, and climate change.

### Overall Research Context:

Some of the greatest challenges in ecosystem science reside at the intellectual interstices between Focus areas 1, 2, and 3. Goal 2 emphasizes integrating projects that (i) provide intellectual linkages across the

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focus area science; (ii) hire new faculty in interdisciplinary areas and provide appropriate Promotion and Tenure rewards and support to ensure advancement of careers in interdisciplinary science and the dissolution of academic barriers; and (iii) expand and foster collaborations among multiple institutions. Among the integrating science efforts that we are taking are the development of statewide climate scenarios, a geospatial database of paleoecological and historical data (ecological legacies), and new frameworks to incorporate microbial metabolic processes into ecological modeling. We have as metric targets to publish multi-authored synthesis papers in Years 4-5 that will connect and integrate the science discoveries that span focus areas. New faculty have been hired with joint appointments in the IoE (0.2) and a home department (0.8) and bring interdisciplinary expertise in bioclimatology (UM), environmental microbiology (pending, MSU), environmental economics (UM), energy policy (MSU), water policy and resources (MSU), surficial processes (pending MSU), and ecosystem modeling (pending, MSU). Future faculty lines are directed to fire ecology (UM), environmental economics (MSU), and limnology (UM). MUS universities with graduate programs are revising their Role and Scope and Promotion and Tenure guideline documents to reward and encourage interdisciplinary research activities and provide a clear understanding of the expectations and review process to ensure strong positive feedback for ecosystem faculty engaged in interdisciplinary research with special emphasis on those faculty with joint faculty appointments. The IoE is developing a mentoring program to support early-career researchers. This program will be formalized before the start of the 2013-14 academic year and will be reported on in our EPSCoR quarterly report this fall semester. The IoE is facilitating multi-institutional participation by creating incentives for increased institutional participation in Focus Area science and creation of a statewide IoE Advisory Committee that has broad inter-institutional engagement across the MUS and tribal colleges.

### Research Objectives

- 2.1 Support portfolio of integrated science initiatives that investigate inter-focus science linkages and synthesis activities and products that benefit all parts of MT-EPSCoR.
- 2.2 Develop a timeline for completion of Focus Area science projects that include expected outcomes for integrative/synthesis products.
- 2.3 Invest in strategic joint-faculty hires in interdisciplinary areas, facilitate faculty participation in the IoE, and develop structures to ensure early-career success in interdisciplinary areas.
- 2.4 Increase the number of inter-institutional teams involved in focus science areas and maintain communication through statewide IoE Advisory Committee

### Implementation and Integration Actions

- Reallocate Year 3-5 funds to support integrative and synthetic products and require inter-institutional participation on all Focus area science activities.
- Increase communication through monthly Focus area science meetings, annual Integration meeting and annual All-Hands Science Summit.
- Finish faculty hires in interdisciplinary areas, listed in the MT-EPSCoR RII Track 1 award, and build critical IoE infrastructure through joint faculty appointments.
- Work with Academic Affairs across the MUS to ensure that Role & Scope and Promotion & Tenure documents reward faculty participation in interdisciplinary research. [Note: the Deputy Commissioner of Research also has as part of their portfolio "Academic Affairs".]
- Develop a mentoring structure that supports the success of early-career researchers in interdisciplinary research.
- Establish a statewide IoE Advisory Committee with broad inter-institutional engagement and participation that meets biannually to discuss strategies and opportunities in ecosystem-related areas.

**Goal 3. Ensure integration of social-ecological systems inquiry in the total portfolio of research capacity in this RII project and its key infrastructure effort, the Montana Institute on Ecosystems (IoE), to better understand ecosystems undergoing rapid change (*Social-Ecological Systems Initiative; see Figure 1*)**

**Social-Ecological Systems Initiative Lead:** Richard Ready, MSU IoE Associate Director

**Targeted Outcomes:**

- The IoE as the statewide hub for understanding the dynamics and resilience of the region's social-ecological systems, especially as they are coupled with natural systems.
- Increased MUS competitiveness to conduct interdisciplinary research on a wide range of social-ecological system topics relevant to Montana.
- Greater engagement of the social sciences within the interdisciplinary research systems framework.

**Overall Research Context:**

Montana's ecosystems and landscapes are undergoing rapid change from drivers that include changes in climate, land use, ground and surface water, and energy development. Understanding these systems and providing new insights into adaptation strategies and resilience-based decision-making requires new understanding of how these ecosystems operate as coupled natural and human systems. Advancing capacity to address social-science components of systems and integrating those perspectives within the natural sciences is critical for Montana's future. In Years 1 and 2, three social scientists were hired with joint appointments in the IoE: environmental economist, energy policy geographer, water resource/policy geography. We plan to hire another environmental economist in Year 3 and environmental policy analyst in Year 4. We see social-ecological sciences as fully coupled disciplines with the natural sciences to achieve robust understanding of the fundamentally integrated problems of Montana's Grand Challenges, now and into the future. As such, we have addressed this as a specific Goal within our Integrative Goals, Objectives, and Activities Plan to ensure integration and specifically overcome tendencies to fall into the silo-trap of discipline separation (also see our Interdisciplinary Research Best Practice Plan).

**Research Objectives**

- 3.1 Use Montana's benchmark ecosystems as natural laboratories for understanding social-ecological systems and their vulnerability to climate change and land-use change.
- 3.2 Engage new faculty hires and existing social science faculty to participate in interdisciplinary ecological research initiatives.
- 3.3 Increase Montana's capacity to tackle social-ecological topics through investment in strategic faculty hires and supporting facilities that address critical research gaps.
- 3.4 Increase number of graduate students receiving training in social-ecological systems areas.

**Implementation and Integration Actions**

- Develop partnerships with local, tribal, state, federal, and NGO entities to expand perspectives, identify needs, and discuss opportunities for collaborative research addressing social-ecological system vulnerability within mountain and high plains regions.
- Provide seed funds to support new interdisciplinary research activities focused on social-ecological systems vulnerability.
- Increase capacity across the MUS in social-ecological systems research through strategic, new faculty hires in critical social science areas, foster new research facilities, and broadly engage faculty participation in IoE activities and mentoring.

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- Support the newly created Systems Ecology PhD program at UM and the Ecology and Environmental Sciences PhD program at MSU in inter-institutional doctoral program collaboration of interdisciplinary ecosystems research including strong representation from social-ecological systems fields.
  - Discuss with NSF-EPSCoR [and submit as needed] any Change-in-Scope Request to enable an increased role for social-ecological sciences in the MT-EPSCoR RII Track 1 award.
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### **Goal 4: Educate and train the next generation of professionals in emerging ecosystem sciences, including those pertaining to social-ecological systems (*Education*)**

**Education Leads:** Cathy Whitlock, MSU IoE co-Director and Maury Valett, UM IoE co-Director

#### **Targeted Outcomes:**

- Statewide IoE graduate programs in interdisciplinary ecosystem sciences.
- New and expanded undergraduate programs available across the MUS and tribal colleges.
- Increased statewide faculty and student participation in IoE activities.
- Improved faculty and teacher training in ecosystem sciences, including social-ecological systems perspectives.

#### **Overall Education Context:**

Goal 4 addresses three areas: (1) graduate education and post-graduate work-force preparation; (2) undergraduate programs, including minors and certificate programs; and (3) teacher/professional development. Currently, the research universities offer PhD and MS options in interdisciplinary environmental science (MSU Ecology and Environmental Sciences PhD; UM Systems Ecology PhD) with little linkage between programs. We seek to integrate these PhD programs to expand curricular offerings, increase training opportunities, and build post-graduate networking in ways that will increase the competitiveness of Montana's MS and Doctoral students. Systems Ecology at UM already has social-sciences as an integral part of their disciplinary portfolio; we are additionally working with social scientists at MSU to develop an interdisciplinary social-ecological sciences PhD program. Current undergraduate opportunities in ecosystem sciences are focused at the research universities. Tribal colleges and MUS non-research institutions are not receiving curriculum or training in critical ecosystem and social-ecological science areas. We are developing on-line courses to facilitate expanded course-work opportunities across Montana; in Year 2 we developed and offered online graduate courses *Environmental Journalism for Scientists (UM)* and *Climate Change for Teachers (MSU - National Teachers Enhancement Network)* and in fall 2013 MT-EPSCoR has worked through the IoE to develop and offer the graduate course *Fundamentals of Ecosystem Science*. Existing undergraduate learning experiences will be broadened through new certificate opportunities, online courses, and colloquia that better serve the tribal colleges and non-research institutions. We will target for Years 3-4 to strengthen content knowledge in climate science through a graduate certificate program and new curricular materials, including science-related activities and non-credit online educational modules.

#### **Education Objectives**

- 4.1 Increase number of PhD students in interdisciplinary ecosystem sciences (including social-ecological systems) through integration of graduate programs in the MUS.
- 4.2 Develop new undergraduate opportunities in interdisciplinary ecosystem sciences through new internships, minor options, and certificate programs; thus also building workforce development.
- 4.3 Improve K-12 to college instruction in ecosystem sciences through professional development opportunities and updated curricular materials for teachers and broader engagement and outreach.

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### Implementation and Integration Actions

- Develop a roadmap for integrating the UM Systems Ecology graduate program and MSU Ecology & Environmental Sciences PhD program. Our target is to develop a statewide graduate program administered within the IoE. This will require institutional support and approval by the Commission of Higher Education and the State Board of Regents. In Montana, this is a 2-year process, minimum. Our goal is to achieve this by Year 5.
- Create online course materials, internships, and minor/certificate options to expand undergraduate training in interdisciplinary ecosystem sciences areas.
- Include faculty and students from across all MUS institutions and tribal colleges in the IoE/EPSCoR colloquia and seminars through online, real-time streaming of video. We will begin this implementation Fall semester 2013.
- Create a graduate certificate programs in ecosystems sciences, including climate change and social-ecological systems, for faculty and teachers that includes development of new curricular materials.

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### Goal 5: Expand and coordinate opportunities for knowledge dissemination and training to improve STEM workforce development (*Workforce*)

**Workforce co-Leads:** Becky Mahurin, MSU and Joe Fanguy, UM

#### Targeted Outcomes:

- A highly functional IoE data portal (also see Goals 6 & 7) to allow diverse audiences across the state to access research discovery and data, new education tools, and community discussion
- Provide science-based data and discussion of implications for climate change vulnerability into decision-making by stakeholders across the state.
- Increase job placement in environmental fields for MUS graduates.
- New private sector partnerships with the IoE.

#### Overall Workforce Context:

Workforce development requires engaging the private sector, especially technology-base start-up companies, focused on green opportunities. It also involves connecting students and faculty with partners in businesses, government, and non-government organizations in ways that are meaningful and substantive. Our science focus on climate change vulnerability requires new efforts to increase climate science literacy and increase entrepreneurship and innovation in sustainable technologies. Better communication and discussion of Montana's future requires information dissemination through online and face-to-face venues. Workforce development in Montana requires that student connect with partners in business and technology-based sectors, state and federal agencies, and the non-governmental organization communities in sustained and meaningful ways. We will work with diverse sectors of the state's economy to seek common ground in charting a sustainable future for Montana. These efforts will make students more employable upon graduation, build sustainable and diverse partnerships, and provide new networking opportunities for faculty and students.

#### Workforce Objectives:

- 5.1 Develop content and cyberinfrastructure tools to engage stakeholders on topics related to ecosystem health, socio-economic development, climate change and natural resource policy.
- 5.2 Facilitate statewide discussions about climate change impacts in Montana.
- 5.2 Formalize opportunities for student training and mentoring with partners from businesses, federal and state agencies, and non-profit groups.



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- 5.3 Build closer relations between the IoE and the private sector through targeted meetings and workshops.

### Implementation and Integration Actions

- Ensure the IoE data portal is accessible, relevant and useable by public audiences.
  - Develop climate-change discussion forums and exhibits for statewide dissemination.
  - Create IoE statewide internship and mentoring program with private, public, and NGO sectors.
  - Participate in private-sector engagement activities underway by MUS technology transfer programs.
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## Goal 6: Engage the full diversity of Montana's human and institutional resources in the achievement of the RII project goals and objectives (*Diversity*)

**Diversity Lead:** Aaron Thomas, UM

### Targeted Outcomes:

- Increased collaboration between MT-EPSCoR science objectives and Montana's tribal colleges in research in ecosystem sciences, including climate change and social-ecological systems.
- Increased success of Native American students in STEM programs.
- Better college preparatory and STEM skills for high-school students among Native American students on tribal reservations.
- Increased number of faculty from underrepresented groups (especially women, Native American) in Montana's universities and colleges.

### Overall Diversity Context:

Because Native Americans make up more 75% of the non-white population in Montana, increasing research and education opportunities for this underrepresented group is our primary focus. A second target of diversity is increasing the representation of women faculty in STEM areas within the MUS. Our diversity plan targets increasing science success for Native Americans and other underrepresented groups in the MUS by improving instruction in ecosystem science and SES at tribal colleges; supporting accelerated math preparation for pre-college, tribal students, increasing numbers of Native American Ph.D. students in environmental sciences, and enhancing faculty diversity through strategic hires.

### Diversity Objectives

- 6.1 Support participation of tribal college faculty and students in MT-EPSCoR/IoE activities.
- 6.2 Provide STEM training and mentoring for Native American students across MUS institutions and tribal colleges to improve retention and graduation rates.
- 6.3 Offer pilot accelerated math program.
- 6.4 Build curricular materials and faculty training on critical ecosystem science and social-ecological systems topics (see also Goal 4).
- 6.5 Increase MUS faculty diversity.

### Implementation and Integration Actions

- Develop tribal college grant program to help faculty and students participate in MT-EPSCoR/IoE - related research activities.
- Increase tribal college faculty and student participation in statewide MT-EPSCoR/IoE events through participation in Focus science areas, seminars and workshops
- Build a IoE partnership with AmeriCorps VISTA to help facilitate research collaborations with tribal colleges.

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- Explore the expansion of NARL as a statewide program to facilitate success of Native American students in STEM disciplines at all of Montana’s higher-education institutions.
  - Expand and update curriculum in ecosystems sciences and social-ecological systems at tribal colleges through online courses, new curricular materials, and teacher training.
  - Support accelerated math program on Montana’s reservation high schools in collaboration with tribal colleges.
  - Hire faculty from underrepresented groups into at least half of the new tenure-track positions that MT-EPSCoR/IOE will fill.
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### **Goal 7. Implement new and integrate existing *cyberinfrastructure* to improve statewide (1) collaboration and communication, (2) education and outreach, and (3) research computing resources that foster integrated outcomes and increase competitiveness in ecosystem sciences (*Cyberinfrastructure*)**

**Cyberinfrastructure Lead:** Todd Kipfer, MSU

#### **Targeted Outcomes:**

- Greater disciplinary and institutional participation in project meetings, events, and workshops by researchers, students, partners, and other project participants within and beyond Montana.
- Expanded engagement with diverse participants and stakeholders through unified discovery and access to project climate change vulnerability and ecosystem databases and products through a new data portal developed as an expansion of the IOE website.
- Data management plan and implementation for Focus Area and Integration science data, models, and products.
- New high performance computing capacity that supports ecosystem modeling.
- Participation by project researchers and technical staff in national programs (e.g., NEON, XSEDE, DataOne) and cyber-collaboration and data management components of regional partnerships (e.g., DOI Great Northern LCC, USGS North Central Climate Science Center).

#### **Overall Cyberinfrastructure Context:**

Montana’s geography and distributed population centers present challenges for statewide collaboration and communication. Further resources to support communication, expanded outreach, data management, visualization, and open access to data and products are not well articulated within and across universities. The IOE will develop targeted cyber-collaboration and cyberinfrastructure by expanding the training and use of technologies for participant and stakeholder communication and collaboration, launching a data portal, creating new planetarium-based model visualization capacity, implementing a project data management plan, establishing new high performance computing capacity, and increasing participation in national and regional partnerships

#### **Cyberinfrastructure Objectives**

- 7.1 Establish a new, broad-participation IOE Cyberinfrastructure Committee to work closely with the Focus science teams (that include Education, Outreach and Diversity components) to help improve communication and collaboration, implement research objectives, address data management needs, and disseminate knowledge and outreach products to stakeholders.
- 7.2 Create a public-access data portal that provides singular discovery of and access to project data, models, and information products.
- 7.3 Expanded use of CI training and tools to increase communication and collaboration among all project participants.

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- 7.4 Develop and implement a data management plan for all integrated science projects.
- 7.5 Develop a model for HPC that supports ecosystem modeling.
- 7.6 Increase MUS engagement with national and regional cyberinfrastructure programs.

### Implementation and Integration Actions

- Establish IoE Cyberinfrastructure Committee to work with project science teams in deliverance of goals and objectives. The CI Committee will be chaired by the IoE Assistant Director.
- Make Rough Cut and Distinguished Visiting Scholar lecture screencasts available live over the Internet and via streaming video archive from IoE website.
- Provide video conferencing tools (e.g., GoToMeeting) for distance communication for all project participants and teams. Ensure all project meetings have a distance communication option for participants unable to be on location.
- Develop a project reporting database that builds on a legacy research reporting database and opportunities to partner with other EPSCoR jurisdictions.
- Expand the IoE website to include a login forum/discussion area for project participants, including file sharing.
- Evaluate and provide expert advice to project participants and stakeholders on emerging technologies for project application, including mobile devices and applications, new video conferencing and social media software, and website development to support file sharing and asynchronous communication and collaboration.
- Develop IoE data portal and backend databases using open source content management framework (metacat). Work closely with Outreach Committee to ensure usability and effective translation of science for target audiences in data and product provision via the portal.
- Populate IoE data portal with project data and information products.
- Partner with Research Computing Group (MSU) and the Numerical Terradynamic Simulation Group (UM) to work with science teams to develop a project-wide data management plan, including evaluation of opportunities to more broadly utilize the MT-EPSCoR RII Track 2 developed VOEIS data management platform and usage of other existing data repositories.
- Facilitate the acquisition and implementation of a new high performance-computing cluster that will be used by the ecological modeler new hire (MSU) as well as other modelers of ecosystem processes across the MUS.
- Provide support to send two project participants annually to national or regional cyberinfrastructure-related meetings or trainings (e.g., NEON, DataOne, XSEDE, NC CSC, GN LCC). Ensure full reporting back to the Cyberinfrastructure Committee and science teams.
- Work with PD and IoE co-Directors to align annual budgeting with CI plan actions to ensure project success.

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**Goal 8. Create and maintain a science outreach network that increases the visibility of the IoE and engages IoE integrated science teams, Focus Area project outcomes, and statewide vulnerability to climate change assessment with stakeholders, focusing on resource managers, decision-makers, STEM educators, and the general public (*Outreach*)**

**Outreach Leads:** Holly Truitt (UM) and Suzi Taylor (MSU)

#### Targeted Outcomes

- A statewide outreach team and outreach leadership for the Education, Outreach, and Diversity (EOD) Integration Committee that increases the visibility of the IoE and provides meaningful and

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measurable engagement of Focus Area science and integrated outcomes with target stakeholders: resource managers, decision-makers, STEM educators, and the general public.

- Inclusion of outreach professionals as participants in Focus Area science teams and research activities, ensuring meaningful engagement of expected and emerging science outcomes with target stakeholders.
- Outreach partnerships with multi-jurisdictional science and resource management programs (e.g., NEON, DOI Great Northern Landscape Conservation Cooperative, Greater Yellowstone Coordinating Committee, Crown Managers Partnership, Governor's Upper Yellowstone River Task Force) science-based NGOs, tribal colleges, and Montana Extension and agricultural communities.
- Quarterly MT-EPSCoR newsletter that connects participants and stakeholders with project progress/updates, events, opportunities, and outcomes.
- Use of IoE website and data portal, exhibits, cyber-collaboration tools, social media, and emerging technologies (e.g., mobile device applications) to provide expanded resources for stakeholder outreach and engagement.
- Improved science communication skills for project researchers and students.
- Production, marketing, and deployment of a statewide report *Montana's Vulnerability on Climate Change*.

### Overall Engagement and Outreach Context

Montana's distinctive and rapidly changing large landscapes are the backbone of Montana's economy and sustainability. These landscapes are nationally and internationally valued for wildland, natural resource, and amenity values. Visitors, students, and scientists from around the world are drawn to Montana. However, Montanans themselves are often unaware of the quality and value of research happening in their own backyard. The science associated with Montana's large landscapes and natural resources provides a unique platform for rich engagement with respect to understanding ecosystem science and climate change vulnerability, including improved social-ecological systems perspectives. This science is vital for resource managers, decision-makers, and the public both cautious about the institution of science and uncertain how to address current and potential future ecological and social change. STEM educators at rural K-12 schools, community colleges, and partner tribal colleges can improve necessary science literacy through outreach programs that engage Focus area researchers, data, and science outcomes with students.

### Engagement and Outreach Objectives

- 8.1 Establish statewide IoE Outreach Committee with expanded institutional participation.
- 8.2 Participate as members of integrated IoE Focus Area science projects to review and align existing and develop new outreach activities and events that directly connect project participants and science outcomes with target stakeholders.
- 8.3 Create an outreach network that connects target stakeholders to a portfolio of outreach activities and events.
- 8.4 Develop and measure metrics of success for outreach activities and iteratively work with Focus Area science teams to improve outreach impact with target audiences.
- 8.5 Build and leverage outreach partnerships with regional multi-jurisdictional science and resource management programs, NGOs, tribal colleges, and Montana Extension and agricultural communities.
- 8.6 Increase the visibility of Montana EPSCoR and the IoE through a statewide newsletter and communication plan.
- 8.7 Explore and develop stakeholder targeted outreach products for delivery through the IoE website and portal, exhibits, cyber-collaboration tools, social media, and mobile device applications.
- 8.8 Offer science communication trainings and events for project researchers, students, and partners.
- 8.5 Design, develop, and deploy report on Montana's vulnerability to climate change.

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### Implementation and Integration Actions

- Expand statewide Outreach Team and recruit members from Montana higher education institutions not currently represented.
- Coordinate and provide outreach leadership for the EOD Integration Committee.
- Convene quarterly Outreach Committee meetings, including representatives from Workforce Development and Diversity teams.
- Participate in national EPSCoR and NSF meetings, events, and workshops to expand multi-state contacts and explore new opportunities for science outreach.
- Embed outreach participant(s) to serve as a member of the Focus Area science teams to collaboratively and iteratively assess and refine current and develop new outreach activities that engage researchers and relevant science outcomes with target audiences.
- Deploy a portfolio of outreach activities and products to build an integrated IoE outreach network.
- Further develop Climate in My Backyard (CLiMB) to expand teacher and student knowledge in ecosystem and climate sciences.
- Expand current SpectrUM exhibits to include additional focus on river science and other Montana ecosystem research for a statewide science roadshow.
- Develop relationships with leaders and outreach professionals from multi-jurisdictional science and resource management programs and NGOs that inform them about Focus Area science and the IoE, and lead to partnerships that expand the IoE outreach network and impact.
- Develop strategic activities, events, and cyber-collaboration and communication products that target increased project participation for tribal college faculty, instructors, and students.
- Convene a workshop annually between Focus Area teams and Montana Extension to explore opportunities for new outreach partnerships that expand the IoE outreach network to include rural agricultural and energy extraction communities.
- Create Montana EPSCoR newsletter, deployed both in print and via the Web to statewide audiences.
- Create user-targeted data and information products that will be delivered through the IoE data portal.
- Develop prototype mobile device application that connects a stakeholder audience with climate change and ecosystem science.
- Expand IoE Rough Cut Science and Distinguished Visiting Lecturer series to increase statewide participation through direct participation, live and archived screencasts, and connection to the portfolio of outreach activities.
- Hold annual science communication series at MSU and UM for researchers, students, and partners.
- Organize a team to design and develop a report on Montana's vulnerability to climate change.
- Market and disseminate the MT-EPSCoR/IoE statewide report *Montana's Vulnerability on Climate Change*.

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### **Goal 9. Develop the IoE as a sustainable, collaborative structure and resource to improve statewide research, education, and science engagement capacity and competitiveness in interdisciplinary ecosystem and SES sciences (*New Institute*)**

**New Institute co-Leads:** Maury Valett, UM IoE co-Director and Cathy Whitlock, MSU IoE co-Director

#### **Targeted Outcomes:**

- Montana Board of Regents approved Institute on Ecosystems.
- Successful integrated implementation EPSCoR project activities through the IoE.

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- Close coordination between the IoE and MT-EPSCoR program ensuring project success and programs positioned for success after this award.
- New IoE initiatives that build on EPSCoR project successes, including faculty hires in ecosystem sciences and social-ecological systems areas.
- An plan for IoE sustainability including a portfolio of funding strategies.

### **Overall New Institute Context:**

The Institute on Ecosystems (IoE) is a Montana community of scholars and partners with a shared vision to advance integrated environmental sciences and related fields across the state of Montana, based within the academic community but with strong partnerships to federal, state, tribal and private interests and stakeholders. The IoE draws on the extraordinary landscapes of Montana and beyond to understand complex ecosystems including the interconnectedness of people and nature. The IoE is the flagship program of the current Montana NSF EPSCoR RII Track 1 award and a first-of-its-kind experiment for Montana to build a statewide institute in any discipline that bridges across all MUS institutions. The vision is the creation of an institute focused on the critically important topic of Ecosystem Science in Montana that is accessible and promotes inclusion of all institutions of higher education within the state, state agencies, NGOs, and private industry with interests in ecosystem sciences, broadly defined. The IoE role is to serve as a research and education portal on ecosystem sciences to the citizens of Montana and the nation by tackling relevant natural-ecological and social-ecological problems associated with ecosystem change. As a knowledge, research and information portal, the IoE provides a fundamental basis for information-exchange and knowledge-based decision-making. Sustainability of the IoE requires a funding model that extends beyond MT-EPSCoR support to be based on new grants, state funding, and private support.

### **New Institute Objectives**

- 9.1 Obtain Montana Board of Regents approval and launch IoE through strategic integration across the MUS with specific targeted reference to MSU and UM strategic plans as the co-home institutions housing the IoE.
- 9.2 Establish IoE statewide leadership and operational structure.
- 9.3 Develop models for faculty and partner integration with IoE activities.
- 9.4 Coordinate MT-EPSCoR research, education, science engagement and infrastructure activities on ecosystem sciences and SES through the IoE.
- 9.5 Develop an MUS role and campus-based funding models for IoE sustainability after this MT-EPSCoR RII award.

### **Implementation and Integration Actions**

- Establish IoE leadership structure and operational hubs at UM and MSU.
- Utilize IoE to integrate and implement MT-EPSCoR RII Track 1 project activities.
- Facilitate participation through joint faculty appointments and clear Promotion and Tenure criteria.
- Develop models for faculty and partner integration with IoE activities.
- Pursue new interdisciplinary initiatives in research and education in ecosystem science extending across natural and social-ecological systems science areas.
- Work closely with the State Science and Technology Committee, the Commissioner of Higher Education, the Presidents of the research universities and respective Provosts and Vice Presidents of Research to develop an IoE sustainability model.
  - Revisit and revise IoE goals and objectives to ensure they align with MUS, MSU, and UM strategic plans and position the IoE for future success.
  - Obtain 5-year post-award IoE leadership and base support commitments for UM and MSU operational hubs, starting Sept 2017. Compensation for each IoE co-director

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should be negotiated individually, and additional minimal base support of \$150K/year/campus is required to provide operational continuity for ongoing success.

- Develop at UM and MSU a grant overhead return funding model that provides an incentive for running select grants through the IoE.
- If possible, align appropriate IoE capacity as a component of the next Track-1 project to develop an additional research focus area for the IoE.
- If the IoE is unable to obtain base support commitments, consider best alternatives for sustaining developed research networks and operations.

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### **Goal 10: Implement an integrated internal assessment and external evaluation program that allows for continual evolution, improvement and fine-tuning of the MT-EPSCoR programs and activities (*assessment*)**

**Assessment Lead:** Ragan Callaway (UM) Montana EPSCoR RII Track-1 PI

#### **Targeted Outcomes:**

- An internal and external evaluation program that provides guidance for continual program improvement and effectiveness.
- Develop tools that enable feedback from all participants and stakeholders.
- The collection and analysis of programmatic data that allows for assessment of MT-EPSCoR program short term and long-term impacts.

#### **Overall Assessment Context:**

The MT- EPSCoR recognizes the need to have internal assessment and external evaluation enhance programmatic integration and effectiveness across institutions and disciplines.

#### **Assessment Objectives**

- 10.1 The generation of accurate and timely data on the effectiveness of all EPSCoR programs and activities.
- 10.2 Improve program integration across the state by using evaluation tools to determine where integration problems exist.

#### **Implementation Actions**

- Develop a new and expanded, internal assessment plan with the newly restructured MT-EPSCoR office.
- Develop a new external assessment plan with the newly restructured MT-EPSCoR office.

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### **Goal 11. Establish the IoE as a lasting statewide research, education, and outreach infrastructure (*Sustainability*)**

**Sustainability Leads:** Cathy Whitlock (MSU) and Maury Valett (UM)

#### **Targeted Outcomes:**

- Successful and visible integrated implementation of MT-EPSCoR project that positions the IoE for future success.
- New IoE interdisciplinary research capacity and initiatives as a result of MT-EPSCoR investments.
- New IoE education and outreach initiatives in ecosystem sciences that leverage new research capacity and improve integration across Montana's higher-education institutions.

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- IoE long-term strategic plan that builds on MT-EPSCoR and aligns with MUS, UM, and MSU strategic goals.
- Sustainable IoE funding model with both institutional and external support.
- IoE governance and operational structure that ensures statewide participation, supports strategic goals, and ensures sustainable funding.
- Visible IoE and MT-EPSCoR programs and brands within the MUS and across the state of Montana.

### Overall Sustainability Context:

The IoE is a first-of-its-kind experiment for Montana to build a statewide institute functioning broadly across the MUS institutions. By leveraging the capacity of the paired university systems (i.e., the MSU-system and UM-system) and other state education partners (i.e., tribal colleges and private colleges), the IoE has the opportunity to achieve far Montana a greater integrated success in the strategic areas of ecosystem sciences, climate change, and social-ecological systems. The IoE's first five years of development are programmatically supported with MT-EPSCoR resources. During this development phase, the goal is to position the IoE to establish new capacity and initiatives through successful implementation of the MT-EPSCoR RII Track 1 project. During this phase, the IoE is developing a long-term strategic plan that includes a sustainable funding model, an effective governance and operational structure, and a visible brand.

The IoE is addressing key issues for long-term sustainability. Structuring the current MT-EPSCoR project in the state and with the IoE has required adaptations for building the IoE. These challenges are an ongoing process of resolution. Long-term sustainability will require base support from the two university systems as well as developing the capacity to obtain external funding. Success at obtaining grants will be important, but we do not feel grants alone can sustain a statewide institute based on interdisciplinary principles, even with additional incentive structures. Working across the geographically dispersed higher education institutions within the state requires new models of collaboration and integration. Improving STEM capacity for underrepresented groups, including faculty and students at Montana's tribal colleges, is a challenge that will require long-term engagement and new and ever-evolving strategies. The IoE has generated widespread enthusiasm across the MUS and fits the strategic plans of the research universities. Thus, we believe with a developing, broad-based support of the Office of the Commissioner and the two university Presidents, these challenges can be overcome.

### Sustainability Objectives

- 11.1 Develop and implement a successful MT-EPSCoR structure and program.
- 11.2 Establish new IoE research and education initiatives that build on MT-EPSCoR.
- 11.3 Strategically align the IoE to address state and the national needs in ecosystem sciences.
- 11.4 Develop an IoE funding model that includes both internal and external support.
- 11.5 Develop the IoE as a statewide organization with engaged governance and efficient operational capacity.
- 11.6 Develop and implement a communications and marketing plan for the IoE.

### Implementation Actions

- Restructure MT-EPSCoR program and organize and oversee integrated project implementation within the IoE.
- Create an IoE external advisory board.
- Develop new IoE research programs in areas of large landscape science and sustainability that leverage MT-EPSCoR project objectives.
- Utilize new social sciences capacity to advance new social-ecological system research initiatives.
- Partner across the MUS, and with federal, state, tribal and NGO programs to develop relationships and strategies for building STEM capacity among Montana's Native American communities.



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- Create a sustainable revenue stream for the IoE based on state/campus-based support and national research priorities.
- Establish staff capacity in communications to develop and implement an IoE communications and marketing plan.
- Feature *Montana's Vulnerability to Climate Change* Report as a keystone science product with a regular, biennial update for the State legislature.