MISSOURI EPSCoR

Strategic Plan

MISSOURI TRANSECT

Missouri Transect: Climate, Plants and Community

Missouri S&T UMSL UMKC Lincoln University Washington University in St. Louis Donald Danforth Plant Science Center Saint Louis University Saint Louis science center

Photo Credits: CAFNR


Credit: Rebecca Ballew

Mission Statement

The Missouri Transect will enhance our state's capacity to model and respond to the effects of climate change on plants and community on a *local* scale.

Executive Summary

The Missouri Transect: Climate, Plants and Community is a statewide collaborative research effort to understand how climate variability impacts plants and communities in Missouri. The project's overall aims are to model and predict (1) short- and long-term trends in temperature and precipitation at the regional and local levels; (2) the effects of these trends on the productivity of Missouri's native flora and agricultural crops; and (3) how different stakeholder communities are likely to respond to these changes. This knowledge will be used to improve the state's overall capacity to respond to climate change by enriching its climate modeling abilities and by enhancing the resilience of plants and communities to potential changes.

The project leverages existing research assets across the state. Among those assets are statewide research strengths in the plant sciences, remote sensing and imaging, atmospheric and environmental sciences, 'omics approaches, and the social sciences; the Interdisciplinary Plant Group at the University of Missouri; Missouri Science & Technology, one of the worlds' leading technological universities; the Missouri Climate Center; the Donald Danforth Plant Sciences Center, an international hub for plant science research; Lincoln University, a Historically Black College and University (HBCU); extensive cyberinfrastructure; several Missouri-based organizations that assist life sciences entrepreneurs build new companies; and the Saint Louis Science Center.

The Missouri Transect is comprised of five interdisciplinary teams: a Climate Team, a Plant Team, a Community Team, a Science Education and Outreach Team, and a Cyberinfrastructure Team. Each team includes researchers drawn from multiple research institutions across the state who are established leaders in their respective fields. Members of the Climate, Plant, and Community Teams bring together their diverse research strengths and approaches to bear on three overlapping research questions: How do short- and long-term climate-scale trends affect crops and the natural flora?; What genes are important to plant responses to these environmental variations? and How resilient are Missouri communities to variations in the climate and its impact on plants? The Science Education and Outreach Team integrates elements of these research efforts into activities designed to enhance STEM—science, technology, engineering, and mathematics—learning across the educational spectrum and among the public. And the Cyberinfrastructure Team provides the computational foundation for all research, education, and outreach activities. The specific aims, activities, and milestones of each team are detailed in this strategic plan.

Expected outcomes from this project include a strong climate monitoring infrastructure with the ability to predict daily, seasonal, annual and future variability; drought-tolerant crops; a regional resilience framework to help Missouri communities respond to climate change; modernization of Missouri's cyberinfrastructure capable of handling "Big Data"; and a more technologically advanced workforce.

Missourians will benefit from this significant investment in a variety of ways. Training and education activities will develop Missouri's STEM workforce. Career training in computation and computational biology will be targeted to women, minorities, and people with disabilities. The project also will fund dozens of new researchers and support staff to create a critical mass of researchers that will contribute to Missouri's broader research community. Discoveries also will lead to new technologies or technology portfolios around which new businesses can flourish in the state. Educational activities also will improve STEM learning among K-12 students and teachers as well as undergraduate and graduate students at participating institutions. Citizen science projects and an interactive science exhibit will engage people from across the state in the research.

More information, including updates over the life of the project, can be found at **espcormissouri.org**

Vision Statement

Missouri EPSCoR will enhance the state's infrastructure for science and technology, stimulating Missouri's economy and leading to job creation.

Missouri EPSCoR

Missouri EPSCoR is an affiliation among colleges and universities, industry and research institutions. Its mission is to enhance Missouri research competitiveness. The Missouri Transect: Climate, Plants, and Community is a project of Missouri EPSCoR.

The Experimental Program to Stimulate Competitive Research (EPSCoR), originally developed by the National Science Foundation, is designed to expand research opportunities in states that have traditionally received less funding in federal support for university research. The program aims to provide strategic opportunities to stimulate sustainable improvements in R&D infrastructure, capacity and competitiveness, and to advance science and engineering capabilities for discovery, innovation and knowledge-based prosperity. Missouri became eligible for EPSCoR funding in FY2012.

Missouri EPSCoR was established in 2012 with receipt of a planning grant from NSF EPSCoR. This grant sought to identify unique assets within the state that, if leveraged together, could provide opportunities for extraordinary initiatives that would boost the state's overall research and technology enterprise. The Missouri Transect: Climate, Plants, and Community is the product of that planning grant and was submitted for funding as a Research Infrastructure Improvement Track-1 (RII Track-1) proposal in 2013. Track-1 awards provide up to $4 million per year for up to 5 years "to support physical, human, and cyber infrastructure improvements in research areas selected by the jurisdiction's EPSCoR Statewide Committee as having the best potential to improve future R&D competitiveness of the jurisdiction." Missouri was one of six states awarded RII Track-1 funding in 2014.

Missouri EPSCoR is an affiliation of the following institutions:

- University of Missouri (MU)
- Missouri University of Science and Technology (Missouri S&T)
- University of Missouri-St. Louis (UMSL)
- University of Missouri-Kansas City (UMKC)
- Missouri State University
- Lincoln University (LU)
- Donald Danforth Plant Science Center (DDPSC),
- Washington University (WUSTL)
- Saint Louis University (SLU)
- Saint Louis Science Center (SLSC).

While overseeing implementation of the Missouri Transect, Missouri EPSCoR continues to identify and pursue other opportunities to enhance the state's research competitiveness and overall scientific and technology enterprise. In 2014, it also was awarded a Research Infrastructure Improvement Track-2 (RII Track-2) grant to establish, in close coordination with researchers from Arkansas, a Plant Imaging Consortium designed to enable innovations in plant science. It is also pursuing opportunities to enhance Missouri's aerospace and aerospace-related research through NASA EPSCoR.

The University of Missouri is the administrative lead for Missouri EPSCoR and the Missouri Transect. Dr. John Walker, Curators' Professor and Director of the Division of Biological Sciences at MU, is the Principal Investigator and Project Director. Other members of the Executive Staff are Dr. Anna Waldron, Associate Project Director, Ms. Emily Haghighi, Project Administrator, and Mrs. Anantha Gopalaratnam, Project Fiscal Officer.

A Statewide Committee that provides direction and oversight for all EPSCoR activities, including the Missouri Transect, governs Missouri EPSCoR. Dr. Keith Gary, Director of Program Development at the Kansas City Area Life Sciences Institute, chairs the Committee, which represents diverse stakeholders from across the state and from all sectors of the economy. Committee members include high-level leaders in the private sector, foundations, and the state government. The Statewide Committee has two subcommittees focused on cyberinfrastructure and academic institutions. The Cyberinfrastructure Subcommittee Chair is Dr. Gary Allen. Dr. Krishna Krishnamurthy is the Academic Subcommittee Chair.

Missouri Transect

The Missouri Transect: Climate, Plants, and Community is a project of Missouri EPSCoR. It is a five-year, $20 million consortium among nine research entities and universities located across the state. The project has a collaborative management approach and is deeply committed to the sustainability of programs and research to increase competitiveness of the state.

The Missouri Transect has a dynamic management approach to ensure that its goals and activities are met. As displayed in Figure 1 (bottom right), Missouri EPSCoR's Statewide Committee has broad governance over the Missouri Transect.

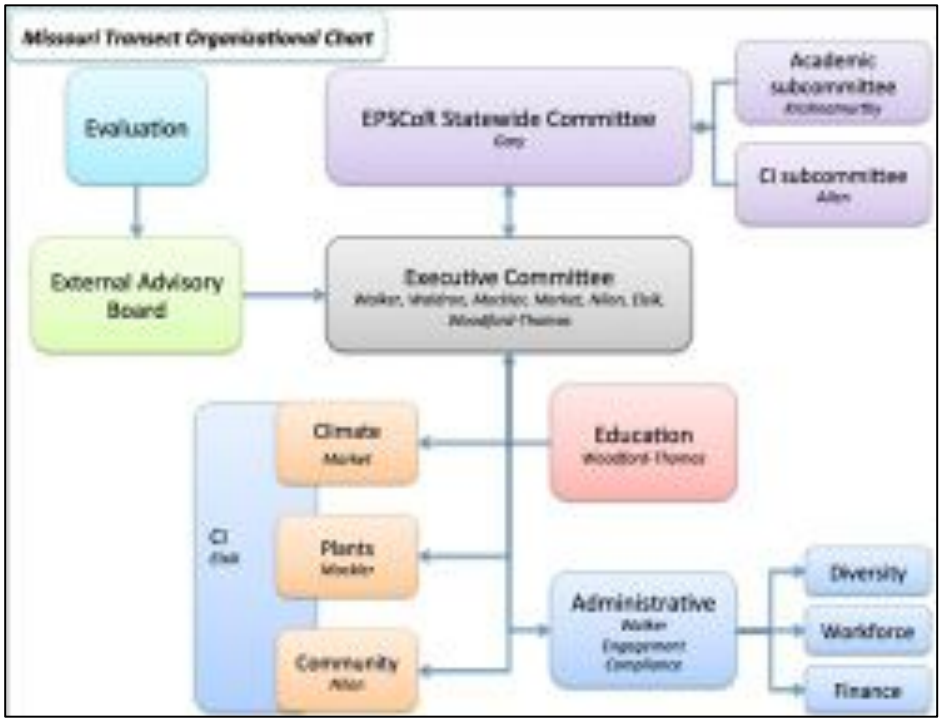
The **Executive Committee** acts as the first tier of management for the Missouri Transect. This committee is composed of the Project Director (Dr. John Walker), the Associate Project Director (Dr. Anna Waldron), the five team leads (Drs. Market, Mockler, Nilon, Elsik, and Woodford-Thomas), and the chair of the Missouri EPSCoR Statewide Committee (Dr. Keith Gary). As Project Director, Dr. Walker is responsible for engagement of all stakeholder groups and reporting and compliance for the project. He and the executive staff oversee the diversity, workforce, and finance efforts.

Each team lead arranges regular meetings with his/her team members and reports activities and results to the Executive Committee. The Executive Committee is responsible for the overall conduct of the project and maintains a daily line of communication among teams, members, and institutions.

The management structure also includes an **External Advisory Board**. This Board works in close contact with an External Evaluator (Dr. Douglas Spenser of Edu, Inc.) and the Executive Committee. Board members serve for five-year terms on the Board, beginning at the start of the award in August 2014. The five members of the Board are located across the United States and are respected academicians in their fields of study. They meet formally once a year to prepare an annual written evaluation of the project, which is disseminated to the Executive Committee, Missouri EPSCoR Statewide Committee, and the NSF. The Board also provides updates on how to improve the project and reviews external and internal evaluation findings, project activities, accomplishments, implementation plan variances, and progress barriers. The Board elected its chair, Dr. Eugene Takle, at the Annual Statewide Meeting in June 2015. Brief descriptions of the five members are provided on page 15.

Sustainability

The research and education teams will leverage the investments made by the Missouri Transect by initiating activities that are inherently sustainable. Such activities include new faculty hires, coursework, creation of a museum exhibit, and seeking ongoing investment from the public and private sector in discoveries. Moreover, the outcomes of Missouri Transect activities will establish a foundation upon which a sustained distributed enterprise can be maintained. While some elements of the Missouri Transect will take a life of their own (for example, start-up companies), the core organization and the experienced leadership will serve the mission well beyond the five years of funding.




Credit: CAFNR

Five interdisciplinary teams – Climate, Plants, Community, Science Education & Outreach, and Cyberinfrastructure (CI) – will coalesce to focus on the continuum of climate change and its impact on communities in Missouri, not as singular endeavors but as one challenge.

Teams Overview

Missouri Transect research and education programs will be integrated by developing learning tools and opportunities that inform individuals of all ages about Missouri climate change and its predicted impact on agriculture and natural resources. The four interdisciplinary teams—Climate, Plants, Community, and Science Education & Outreach—will work in conjunction with the CI team. Over the five-year investment, team members will collaborate throughout the state at partner institutions and will combine their research, education, and outreach efforts with the other teams. Figure 2 (bottom right) illustrates the intersecting relationships between teams and among the entire research consortium.

The teams assembled have a range of expertise, experience, and capabilities in research, education, diversity, outreach, and commercialization. Team members are drawn from participating institutions and are leaders in their respective fields. Each team will bring in an array of stakeholders from around the state, from K-16 students and educators to state government representatives, landowners and community cooperatives to large research organizations.

Climate Team

Dr. Patrick Market is the Climate Team lead. He is the Department Chair and Professor of Atmospheric Science in the School of Natural Resources at the University of Missouri. The Climate Team includes researchers from MU, SLU, and UMKC.

Plant Team

Dr. Todd Mockler is the Plant Team lead. He is Associate Member and Distinguished Investigator at the Donald Danforth Plant Science Center. The Plant Team includes researchers from DDPSC, MS&T, MU, and WUSTL.

Community Team

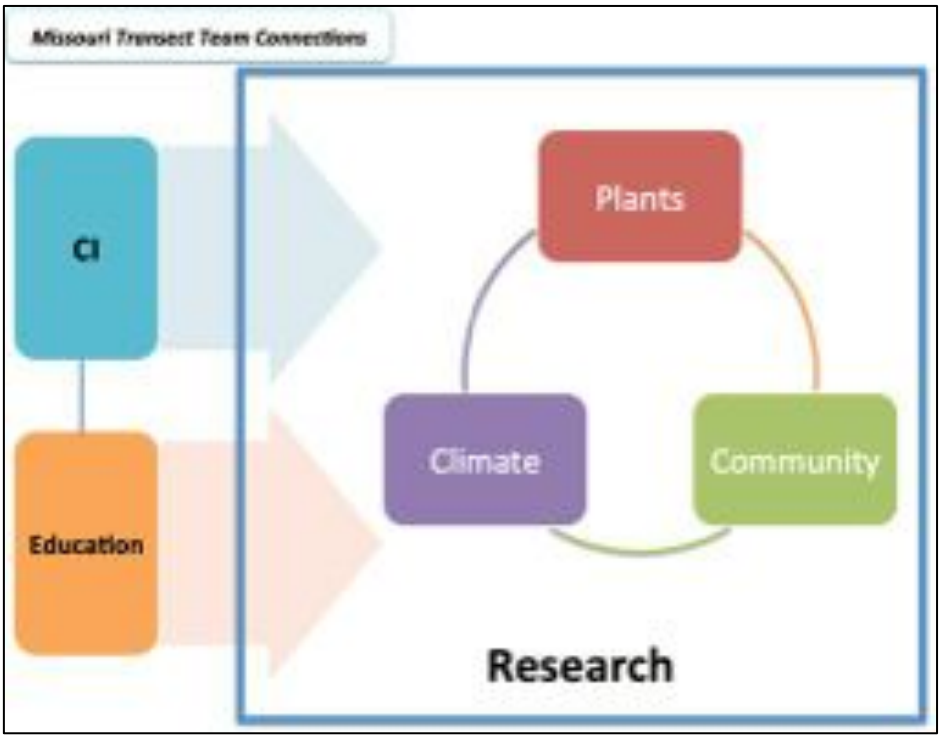
Dr. Charles Nilon is the Community Team lead. He is Professor of Fisheries and Wildlife in the School of Natural Resources at the University of Missouri. The Community Team includes researchers from MU, LU, and UMSL.

Science Education Team

Dr. Terry Woodford-Thomas is the team lead for the Science Education and Outreach Team. She is the Director of Science Education and Outreach at DDPSC. Team members come from LU, MU, SLSC, and WUSTL.

Cyberinfrastructure Team

Dr. Christine Elsik is the Cyberinfrastructure (CI) Team lead. She is a computational biology and bioinformatics expert and Associate Professor of Animal and Plant Science at MU. Team members come from WUSTL and DDPSC.




Credit: CAFNR

The goal of the Climate Team is to model how short- and long-term climate-scale trends in precipitation and temperature affect plant ecosystems and agriculture.

Climate

The Climate Team carries out research to enable predictions and modeling of climate-scale trends in precipitation and temperature as they impact plant productivity. The relationship with the Plant Team cuts across all of the activities of the Climate Team. The critical question that will be addressed is, how do seasonal-scale changes in temperature and precipitation affect the productivity of crops and the natural flora? The Climate Team will consider changes that have occurred across temporal scales, from days to decades, and utilize newly available high-resolution datasets as the basis for integrated and interdisciplinary climate and hydrology research.

In Year 1, the Climate Team will install weather sensors and train personnel to analyze data outputs. Microclimates will be identified and storm track datasets built, and high-resolution maps of rainfall will be developed that will be used throughout the project's duration. Data will augment Plant Team activities (Aim #3).

In Year 2, data from the installed sensors will be collected and analyzed, initiating the process that will continue through Years 3-5. Analytical methods will be completed in Year 3, and from these data, models will be calibrated to explain hydrological events and crop water usage (Year 4). Climate Team members will refine outlook algorithms based on greater knowledge of crop phenotypic variation provided by the Plant Team. In Years 4-5, these models will be validated to assist in their use for projecting future events. Throughout all of these efforts, the Climate Team will improve the resolution of its data collection and models to account for microclimate changes that might otherwise be overlooked as it relates to the impact on crop productivity and the native flora. Integration of these models across different scales will be a challenge met in Years 3-5.

The Climate Team will also understand the impact of climate change and the extreme weather events that challenge the resilience of the ecosystem and the communities that are dependent upon them. A focus on extreme weather will evolve from an initial effort to establish a database (Year 1) through additional efforts to determine the impact of global warming on the jet stream (Years 2, 3).


Credit: CAFNR

- Aim 1: Provide quantitative understanding of precipitation over a multi-use complex terrain.
- Aim 2: Improve seasonal-range climate outlooks.
- Aim 3: Evaluate climate change projections on wetland plant growth.
- Aim 4: Estimate future hydroclimates in Missouri with climate models.


Credit: CAFNR


Credit: CAFNR

The goal of the Plant Team is to identify genes important to plant responses to environmental variations, especially water availability, with the view toward enabling the quick and efficient identification of high-yielding, stress-tolerant plants.

Plants

In Year 1, the Plant Team will collect and generate sufficient maize seed stocks, of different genetic backgrounds, for field and controlled environmental screening under water limiting conditions. Initial phenotypic screens, conducted both in the field and in a controlled environment (Year 1), will identify the most promising genetic populations for field trials and for phenotyping under controlled environmental conditions (Year 2). Phenotyping under controlled conditions will continue and a second field trial will be undertaken in Year 3.

In Year 4, genotypes that show significant differences under water-limiting conditions will be used to identify the variation and genes associated with the phenotype. Phenotypic analysis and genotype-phenotype associations will be conducted that take into consideration environmental parameters shared by the Climate Team. Gene expression profiling of leaves, seeds, pollen, flowers and roots will be initiated with the selected lines. Additional field trials will be undertaken in Years 4- 5. Year 5 activities will continue to focus on gene identification, gene expression profiling and data analysis aimed at correlating gene expression with phenotype.

In parallel with the analysis of plant phenotypes using existing technologies will be the development of advanced imaging capabilities and robotic platforms to facilitate high-throughput data collection.

In Year 1, hardware for hyperspectral imaging of plants will be optimized. Sensor and data specifications for ground vehicles will be defined and initial field trials with AGVs and UAS will be undertaken to collect sufficient data to begin software development for image analysis. In Year 2, the newly developed sensors will be added to the robotic platforms and used for the Year 2 field trials. Software development to define spectral phenotypic signatures will be developed and these signatures will be validated using established molecular, physiological, and chemical analysis methods. Imaging processing and modeling will begin in Year 2 with the goal of having initial ecosystem models developed by the end of Year 3. Ecosystem models will be informed by both phenotypic data generated by the Plant Team as well as environmental data generated by the Climate Team. Advanced imaging technologies will be fully deployed in the Years 3-4 field trials.

Software for data processing image analysis will be refined and correlations between phenotypes and genotypes using the advanced imaging technologies will then begin. A searchable image storage depository will be developed in Years 4-5.


Credit: CAFNR

- Aim 1: Identify genes that confer drought tolerance and improve yields in crops.
- Aim 2: Develop and deploy imaging and remote-sensing technologies to understand plant response to environmental variation.
- Aim 3: Monitor plant health, growth and responses to the environment with remote optical sensing.
- Aim 4: Associate phenotypes with genotypes and environments and model plant productivity in changing environments.


Credit: Emily Haghighi


Credit: CAFNR

The goal of the Community Team is to understand how Missouri communities have reacted to environmental catastrophes and how to achieve resilience under a changing climate characterized by increased periods of drought, flooding, and prolonged summer heat waves.

Community

The Community Team aims to understand how Missouri communities can manage for resilience under a changing climate. The research undertaken by this team will inform understanding of the community-level effects of climate change by considering how diverse stakeholders make decisions in response to drought, storm events, and impacts of vegetation. Research in this area will use historical and archival data to investigate resiliency in urban settings, among land owners/managers and vulnerable populations, and in state parks and historic sites and then to integrate these responses into a resilience framework for Missouri.

In Year 1, the Community Team will identify stakeholders across the state who will be directly involved in the research effort. The Team will complete a detailed review of Missouri's preparedness infrastructure to assess its ability to work with communities to anticipate threats associated with climate, to reduce the impact of these threats by taking preemptive action, to respond appropriately when these threats materialize, and to recover afterward. This assessment will be incorporated into an integrated mapping process, which will allow the Team to work directly with selected vulnerable communities with varying degrees of adaptive capacity. The team will identify and collect archival sources of data and determine resilience indicators. Newspaper accounts surrounding catastrophic events, public discussions of environmental threats in popular and governmental literature, maps depicting changes in land use, and governmental reports documenting changing environmental conditions will combine to help the team determine these resilience indicators. A Community Commons portal will be established to enable communications within and beyond the team. By Year 3, a Virtual City environment that visualizes changes in the urban landscape related to historical response patterns will be completed and implemented.

Between 2000 and the present, Missouri State Parks and Historic Sites have been interrupted and/or closed due to several weather-related events and other natural disasters. The Team will assess resiliency by examining the relationship between park visitation and types of weather-related events and natural disasters. In Year 2, inventory and survey instruments will be completed and priority communities and parks identified. These communities will participate in survey implementation in subsequent years. In Year 4, the Team will interview park managers and complete community resilience studies across the state.

Land management occurs at a variety of scales, from homeowners or residents making decisions about an urban lot to decisions made on farms of several thousand hectares. Managing for resiliency requires an understanding of stakeholders and land managers' preferences and desired outcomes and how these influence management goals and management techniques. In Years 1 and 2, land management practices will be identified for further study. This will lead to the establishment of a community-focused discussion of land management practices and responses to climate events. In Years 3-4, the Team will develop management scenarios based on potential changes in climate and evaluate them with community members. All community planning documents and facilitated workshops will be completed in Year 5.

- Aim 1: Find long-term patterns of response to environmental disruptions.
- Aim 2: Assess management goals and techniques to climate-related threats by landowners, land managers and vulnerable populations.
- Aim 3: Examine the effects of weather-related events and natural disasters linked to the response from Missouri State Parks and Historic Sites.
- Aim 4: Integrate responses to climate change within a regional resilience framework.


Credit: CAFNR

The goal of the Science Education and Outreach Team is to develop learning tools and opportunities that inform individuals of all ages about climate change and its predicted effects on state agriculture and the natural environment.

Science Education & Outreach

Public education programs will be designed to help students, teachers, and citizens understand how the changing environment affects plants and their ability to adapt to temperature changes and water availability, and the ultimate impact of this on communities. Public education programs will share information about how scientists study climatic change, the state-of-the-art approaches to uncover plant drought/stress tolerance traits, and computational ways to extract valuable information from large datasets.

In Years 1-2, the Team will conduct a statewide needs assessment to determine specific resources and professional development needs of K-12 teachers for STEM teaching and learning related to Missouri Transect themes. The results will be used to inform program development and dissemination of materials throughout the state. An initial set of learning modules will be created and piloted in Years 1-2, with subsequent modules developed in the years thereafter based upon research outcomes. Professional development for teachers will be implemented to help integrate these learning materials into the classroom.

Science outreach programs will include an interactive exhibit at the Saint Louis Science Center. The exhibit, which will be designed to immerse the public in the latest scientific developments in Missouri Transect research, will be completed by Year 3. A new citizen science program, MO DIRT, will also be developed beginning in Year 1. Tools, kits, and the interactive website will be developed first, and the program will recruit participants in Years 2-5. Data sharing with stakeholders will commence upon data input into the website with quality control and data validation being an essential component.

A new Women's Summer Computer Science Institute at the Danforth Plant Science Center will be conceptualized and implemented in Year 1 with subsequent offerings at locations throughout Missouri in Years 2-5. This institute, co-taught by researchers and educators, will provide participants with basic skills in computational biology and give them a glimpse into the interdisciplinary nature of Missouri Transect research.

New coursework in computer science will be developed at Lincoln University to enable its students to participate in the research of the Missouri Transect. An undergraduate research seminar will be developed along with a new course in computational intelligence. Prior to developing these courses, a survey will be distributed to Missouri Transect researchers to determine how best to tailor the coursework to the needs of the project, thereby providing targeted preparation to LU undergraduates for summer research opportunities. These courses will be offered starting in Years 1-2. Options to make these courses available to students at other Missouri Transect sites will be explored during Years 3-4. Internships for LU students will be made available each year of the program, enabling students to determine research pathways for post-baccalaureate study.

- Aim 1: Develop new discovery-based STEM learning modules for students and K-16 educators.
- Aim 2: Design a citizen science project on climate-soil interactions and recruit participants statewide.
- Aim 3: Create an interactive outdoor food and agriculture exhibit at the Saint Louis Science Center.
- Aim 4: Offer an annual summer institute on computer science for women.
- Aim 5: Provide research internships in computer science for LU undergrads.


Credit: CAFNR


Credit: DDPSC

The Cyberinfrastructure Team will collaborate with the research and education teams and leverage existing resources to increase high performance computing, storage, and visualization capabilities through EPSCoR dedicated servers.

Cyberinfrastructure

The Cyberinfrastructure (CI) Team will support all program elements of the Missouri Transect. A strong CI infrastructure is required to support the diverse project elements and to integrate computational resources across the project. The challenges of dealing with large, diverse data sets will be addressed by the CI Team in collaboration with the other team leads and investigators. The team lead will work closely with the Project Director to assure that CI needs are identified and addressed as the project develops.

In Year 1, the CI Team will hire a database programmer/analyst to serve as a CI resource to researchers and project staff. This person will work with faculty and MU Research Computing to acquire and configure managed hardware and develop CI user tutorials to enable the research and education efforts to move forward.

In Years 1-2, the CI Team will assess the education and research needs among the various Missouri Transect teams. The full scope of IT needs will be established through distribution of a data management survey (administered in Year 2), a tutorial that outlines best practices in data management, and data management plans prepared by individual research groups. Following a needs assessment, the CI Team will begin efforts to integrate data among the Missouri Transect teams. A research data portal will be established (Year 2) and a data schema implemented (Year 3) in support of this aim.

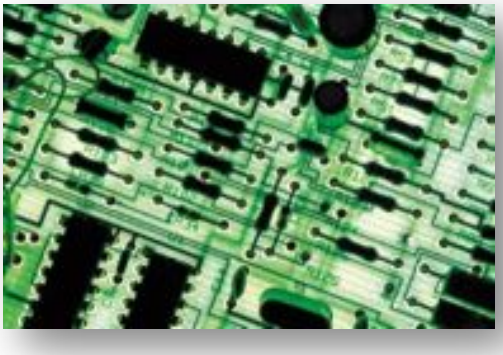
In Year 3, the CI Team will identify the best approach to make selected research datasets available to the public and to external researchers. An external research data portal will be developed in Year 4. Development of web portals and data schemas will continue throughout the project as new research and education needs arise.

In addition to supporting data management needs, the CI team will identify and support research algorithm needs throughout Years 1-5. To support analysis of large image, sensor and climate datasets, the CI Team will develop a large-scale algorithmic framework for sparse learning and a parallel classifier. These algorithms will be available for use by other teams in Year 3 and released as open source in Year 5.

The CI Team will collaborate with the Science Education and Outreach Team on the development of bioinformatics resources, the Women's Summer Computer Science Institute, courses at Lincoln University, and learning resources for the physically disabled. Additionally, graduate students will be trained in data management processes through Years 1-5, which will lead to seamless integration of data between teams by Year 5.


Credit: Christine Elsik

- Aim 1: Ensure that computational resources meet the needs of participants across all campuses.
- Aim 2: Support research platforms by facilitating data transfer, access, analysis, interoperability and preservation.
- Aim 3: Serve as a platform to train a workforce in the use of Cyberinfrastructure.
- Aim 4: Provide publically accessible portals to datasets, analytical tools, and educational resources.



OUTCOMES


Credit: CAFNR

Education & Human Resource Development

Diversity

The Missouri Transect will actively recruit and engage a diverse population of individuals and organizations throughout all aspects of the project. The project will expand minority recruitment into STEM by creating new computer science courses and a new internship program for students at LU. Annual summer institutes on computer science for female high school students and undergraduate students will provide career training in and exposure to computation and computational biology. The project also specifically targets people with physical disabilities as an untapped resource for filling high-skilled bioinformatics jobs.

LU, an HBCU, is a critical partner in Missouri Transect's leadership and all its research, education, and outreach activities. LU's involvement will help ensure the proposed infrastructure investments enhance the participation of underrepresented groups, especially African Americans, in Missouri's research and workforce.

New Faculty Hires

Education and human resource development are investments in the future. They represent both people and educational activities, each of which has a long-lasting impact. The Missouri Transect will support the hire of four or five new faculty across the partner institutions (Figure 3). These hires will strengthen the overall mission of EPSCoR Missouri, which is to enhance Missouri's overall research competitiveness. The Missouri Transect will provide start-up funds to these new hires, and they also will be eligible to compete for seed funding within the project.

Missouri Transect will establish a mentoring program to ensure the long-term success of new faculty. New faculty members will be integrated into one of the four core teams (climate, plants, community, or science education and outreach) and will be mentored by the core members of the team. They will be encouraged to apply for NSF CAREER awards, to utilize all the resources of the Missouri Transect teams, and to increase their scientific network through interactions with members of the EPSCoR Missouri Statewide Committee (or its Academic and CI Subcommittees) and the External Advisory Board.

New Coursework

The Missouri Transect will establish new undergraduate courses in computational intelligence and informatics. These courses will be integrated into the curriculum at LU, with course modules shared across the Missouri Transect institutions.

Outdoor Permanent Exhibit

Missouri Transect will fund the design and construction of a permanent, outdoor interactive science exhibit at the Saint Louis Science Center. The exhibit will be one of the sustained legacies of the Missouri Transect and will present a dynamic living entity that will help communicate scientific discoveries related to the intersection of climate, plants, and community. It also will serve as a sustained nexus for community outreach and citizen science programs both in St. Louis and throughout the state.


Credit: SLSC

Summary of New Faculty Hires

Institution	Discipline	Gap
MU	Systems Biology	Scientists who can integrate empirical and computational approaches to address important questions in biology
Danforth	Phenomics/Bioinformatics	Scientists who use empirical approaches and analytics to elucidate how plants respond to the environment
UMKC	Climate	Scientists with the expertise to analyze and model climate data
LU	Social Sciences/Agriculture	Researchers who study community engagement in impoverished areas
MS&T	Engineering	Scientist that can apply remote sensing approaches to climate and environmental applications


Credit: CAFNR

The Missouri Transect workforce development plan will focus on providing training in the next-generation skills needed for data-driven science, coupled with job creation to ensure high-quality career options.

Workforce Development

Missouri Transect will build on existing degree programs at partner institutions to expand the reach and scope of coursework, research, internship, and fellowship opportunities for post-secondary students across the state. Undergraduate and graduate students will discover how their education translates to the working world by pursuing relevant fellowships, which will be advertised on the Missouri Transect website beginning in Year 1. Undergraduates also will be encouraged to get hands-on, work-related experience with research by taking advantage of different fellowship programs at each partner institution, including MU's McNair Scholars Program or NSF REUs at DDPSC, WUSTL and MU. The Missouri Transect will help build a statewide community of undergraduate researchers, whose focus is climate-plant-community.

A critical area for development in Missouri is bioinformatics training. The Missouri Transect recognizes this as an opportunity in workforce development by training individuals in the field of bioinformatics and helping to take advances made in the field into development in the private sector. Advances in bioinformatics will translate into jobs at start-up companies and in existing private-sector industries. Additionally, academic institutions can assist the private sector by integrating bioinformatics tools and knowledge into their product development and manufacturing processes. The Missouri Transect will design a new program, beginning in Year 1, to train physically disabled students to work within the field of bioinformatics. In Year 1, a review of Vocational Rehabilitation resources will be completed to determine specific areas of need. New computer science internships will be established for undergraduates with disabilities. In Year 2, students with spinal cord injuries will be recruited to participate in bioinformatics training programs. Trainees will work with CI, Climate, and Plant Teams to refine software and user interfaces for analysis and integration of phenomic, genomic, and environmental data. Trainees with spinal cord injuries will have access to the latest assistive technologies, including voice and breathe control actuators, speech input systems, and modified keyboard and mouse devices. These programs will continue in Years 3-5.

The Missouri Transect will also stimulate job creation by directly and indirectly participating in new ventures and start-up companies. In Year 2, a Commercialization Committee will be formed to review technologies and/or unique applications of technology developed through this project for commercialization potential. The Committee will be comprised of industry representatives from the Missouri EPSCoR Statewide Committee, technology transfer professionals, and both angel and venture capital investors. Technologies deemed commercially viable may form the core of a new start-up company, be licensed to an existing company, or bundled with other technologies for a start-up or existing company. Several Missouri-based organizations (e.g., Biogenerator, BioSTL, Center for Emerging Technologies, Center for Innovation and Entrepreneurship, Kauffman Foundation, MO SourceLink) assist life sciences entrepreneurs build new companies and leverage them for economic development. Missouri Transect will facilitate other elements important to startup creation, including nurturing a pool of potential entrepreneurs, providing incubator facilities, and cultivating venture capital funding. Existing programs that contribute to these goals include the Missouri Technology Corporation (MTC), the St. Louis Economic Development Council, and the Ewing Marion Kauffman Foundation. Successful startup companies will be used as models for promoting the commercialization of the intellectual property generated by this investment and the creation of jobs to advance opportunities in workforce development.

- Aim 1: An undergraduate and graduate student training that focuses institutionally relevant degrees and certificates.
- Aim 2: The development of bioinformatics training modules with an emphasis on reaching out to the physically disabled.
- Aim 3: Create jobs through the translation of research discoveries into new ventures and start-ups.

Communication & Dissemination

Missouri Transect's knowledge transfer activities will include intellectual exchanges and the sharing of resources among partners, including minority-serving institutions, nonprofit organizations, educators, farmers, state agencies, industry and the general public. Interactive thinking is critical for creating the tools that enhance our understanding of the impacts of climate change on agriculture and the natural environment. Annual meetings, team meetings, and conferencing via video, telephone, and the web will be used to ensure internal knowledge sharing. Research focus meetings, inter-lab visits and exchanges, and multi-site research internships will promote knowledge exchange and institutional advancement. The technological and cyber-based tools developed by Missouri Transect members will build capacity and interactivity. Inherent to the project is the development of a strong cyberinfrastructure that will connect scientific teams to each other, to the scientific community, and to the public with multiple accessible interfaces.

Gains made by the Missouri Transect as the research activities gain momentum in Years 3-5 will be a rich source of data and knowledge for other researchers. Descriptions of new technologies, method development, software, imaging information, climatic and bioinformatics datasets, and citizen science data and interrogation results will be disseminated through the Missouri EPSCoR website, project-related websites, peer-reviewed journals, and through informal and formal presentations at meetings and conferences. Genomics datasets (genotypes, raw RNA-seq data, summarized gene expression profiles) will be submitted to public archives, including iPlant and the National Center for Biotechnology Information's Sequence Read Archive (SRA) and Gene Expression Omnibus (GEO). Phenomics datasets (raw images, metadata, processed images, summarized digital phenotypes) will be submitted to iPlant and hosted on the Missouri EPSCoR website. The data mining and visualization tool that allows for broader analysis opportunities of radar data from the Missouri Climate Center will involve a THREDDS server for the dissemination of archived data collected by the project radar and a real-time website that will allow access to current data from the radar.

Beginning in Year 1, NSF program officers from areas related to the Missouri Transect research and education programs will be invited to annual meetings to experience the breadth and depth of outreach efforts. Education of faculty, staff, partner organizations, and postdoctoral fellows about NSF funding opportunities will sustain and increase statewide competitiveness and stimulate additional growth and development. Travel support for the project directors and team leaders to meet with NSF Program Officers with respect to current and future funding opportunities is provided.

In addition to undergraduate, graduate and postdoctoral students, the Missouri Transect will reach out to other trainees (out-of-state undergraduates, high school students, disabled students, citizen scientists) throughout the life of the project. Undergraduate coursework and research experiences at Missouri Transect institutions, particularly Lincoln University, will expose next generation scientists to research. In addition, work with vocational and rehabilitation specialists and the rich knowledge and experience gained from bringing a diverse range of individuals into the project (underrepresented minorities, women, physically disabled individuals, non-scientists though citizen engagement) will be shared with the community-at-large through media networks, publications, and presentations.

Educational resources and opportunities developed through the Missouri Transect will shape how Missouri and the nation respond to the projected effects of climate change. The research will provide technologies to advance knowledge needed to understand climate change and its impact on crops and natural environments, which, in turn, will increase the supply of food, biofuel, and feedstocks in Missouri.

- Aim 1: Share scientific knowledge among partner institutions.
- Aim 2: Share data, resources, and scientific findings with scientific community.
- Aim 3: Facilitate engagement of NSF Program Officers.
- Aim 4: Transfer knowledge to science and technology students.
- Aim 5: Facilitate exchange among scientists, STEM educators, and advocacies for the educational advancement of underrepresented students.
- Aim 6: Transfer knowledge and enthusiasm for science and the research process to K-16 students, the public, and policymakers.
- Aim 7: Transfer knowledge to sustain and increase agricultural productivity to farmers, state agencies, and agribusinesses across the state.

The Missouri Transect External Advisory Board is composed of the world's leading experts in the fields of plants, climate and community.

External Advisory Board

An External Advisory Board will help manage and evaluate the Missouri Transect. Membership on the Board will be for a five-year term with all members starting upon initiation of the RII award. The Board will consist of the following five members: Drs. Rob Last, Gail McClure, Bonnie Bartel, Muriel Poston, and Gene Takle. The Chair will be elected at the first Annual Statewide Meeting held in June 2015.

The Board will meet formally once a year but will be provided with regular quarterly updates and real-time information, as necessary. The Board will be charged with identifying strengths, weaknesses, and recommendations for program improvement; evaluating program progress and suggesting corrective actions; and reviewing progress toward achieving outcomes of the strategic plan. The Board will review project update reports: external and internal evaluation findings, project activities, accomplishments, implementation plan variances, and progress barriers, and will prepare an annual written evaluation of the project, which will be disseminated to the Executive Committee, EPSCoR Statewide Committee, and NSF.

Dr. Eugene Takle, Chair –
Iowa State University
Ames, Iowa

Takle is the Director of the Climate Science Program at Iowa State and Professor of Agricultural Meteorology. He is a Fellow of the American Meteorological Society (AMS), AMS Commissioner for Education & Human Resources, and a Board of Trustees member of the University Corporation for Atmospheric Research. He was a contributing author for the 2001 IPCC climate change report and is coordinating lead author for the 2013 US National Climate Assessment.

Dr. Rob Last – Michigan State University
East Lansing, Michigan

Last was recently appointed as the Director of the NIH Training Grant Program, "Plant Biotechnology for Health and Sustainability." He is a Barnett Rosenberg Professor in the Departments of Biochemistry and Molecular Biology and Plant Biology at Michigan State University. From 2003-2004, he served as Program Director of the Plant Genomics Research Program at NSF.

Dr. Gail McClure – ASSET Initiative
Little Rock, Arkansas

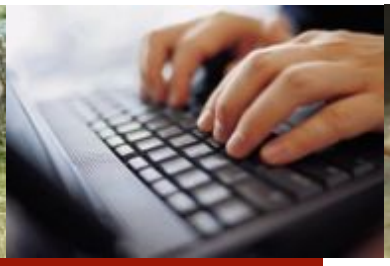
McClure is the Arkansas EPSCoR Executive Management team leader, PI for the Arkansas RII ASSET Initiative, and chair of the EPSCoR Program Director's Council.

Dr. Bonnie Bartel – Rice University,
Houston, Texas

Bartel is the Ralph and Dorothy Looney Professor of Biochemistry and Cell Biology at Rice University, a 2013 American Academy of Arts & Sciences elect, a fellow of the American Society of Plant Biologists, and a Howard Hughes Medical Institute Professor.

Dr. Muriel Poston – Pitzer College
Claremont, California

Poston is Dean of Faculty and Vice President for academic affairs at Pitzer College. She is the former division director for Human Resource Development Division at NSF, where she lent expertise and vision to eight NSF programs focusing on minority institute support and under-represented groups in STEM disciplines.

Appendices

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Appendix A. Baseline Data

Category	8/1/11-7/31/12		8/1/12-7/31/13		8/1/13-7/31/14		Cumulative Total for Prior 3 Years	
Federal Agency Proposals / Grants / Contracts	*Number*	*Funds requested*	*Number*	*Funds requested*	*Number*	*Funds requested*	*Number*	*Funds requested*
Submitted	58	$93,861,939	47	$110,858,781	74	$118,589,400	179	$323,310,120
Awarded	39	$14,073,500	19	$16,840,986	16	$4,106,780	74	$35,021,266
Pending	0		0		24	$49,269,868	24	$49,269,868
Published Publications	122		110		139		371	

Appendix B. Timelines

CLIMATE TEAM				
Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
All weather sensors installed, Y1 (Hubbart)	Weather sensors maintained	Methods of analysis finalized: precipitation (dos) vs. precipitation (radar) (Hubbart)	Hydrology model(s) calibrated/validated with corrected radar data (Hubbart)	Weather sensors maintained
Radar Online, April 2015 (Guinan/Lupo, Fox, Market)	Regular radar products produced and available (Fox, Market)	Radar maintained and used for researcher, community and educational purposes	Radar maintained and used for researcher, community and educational purposes	Radar maintained and used for researcher, community and educational purposes
Three operational online real-time weather stations (Guinan, Travlos)	Weather stations maintained and data collected	Weather stations maintained and data collected	Complete validation of crop water use models (Guinan, Travlos, Market)	Weather stations maintained and data collected
Identify RCM-GCM pairs to downscale (Svoma)	Current Climate to Mid-21st century climate change determined at high spatial resolution for temperature (All RCM-GCM pairs completed) (Svoma)	High-resolution climate change projections for precipitation completed (all RCM/GCM pairs) (Svoma)	Study of Mid-21st century change and uncertainty in hydroclimate initiated	Study of Mid-21st century change and uncertainty in hydroclimate completed (Svoma)
Familiarize GRA with computing equipment and programming environment (Svoma)	GRA continues research	Wetland plant-climate-soil greenhouse studies completed, Y3 end (Goyne/Webb)	4 KM climate change projections of soil water budget completed (all RCM-GCM pairs) (Svoma)	
Identify Missouri microclimate clusters (Svoma)	Wetland plant-soil-climate field studies initiated	Wetland plant-soil-climate field studies continued	Wetland plant-soil-climate field studies continued	Wetland plant-soil-climate field studies completed (Goyne/Webb)
Validate downscaled temperature (Svoma)	LRF Statistics expanded (Lupo, Market)	Climate outlooks provided. Mostly seasonal out 1 year ahead. 1-2 publications, Y3. Verification stats generated (Lupo, Market)	Climate outlooks verification statistics generated and available for use (Lupo & Market)	Upscaling of wetland plant response to projected climate "map" (Goyne/Webb, Svoma)
Data for LRF analyzed & built model for LRF (Lupo, Market)	LRF model built (Lupo, Market)	LRF continued	LRF continued	LRF continued
Extreme weather: create storm track datasets.	Website redesigned & online (Lupo, Market)	Extreme weather: determine how the storm track changes due to global warming (Eichler)	Extreme weather: determine if El Nino responds to climate change (Eichler)	Extreme weather: Determine if storm structure is altered due to climate change (Eichler)
Extreme weather: analyze rainfall linked to storms	Extreme weather: Assess how to the low-level jetstream may change due to global warming (Eichler)		Extreme weather: assess implications on storm tracks and precipitation (Eichler)	
PLANT TEAM				
Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Hardware: Optimize hyperspectral image acquisition for plants, leaves, seeds, pollen, end Aug. 2015 (Berezin, Holdo, Yin)	Image analysis: Develop software to generate optical signature of species, end Aug. 2016 (Berezin, Holdo, Mockler, Yin, Fritschi, & CI team)		High-throughput analysis of real samples to correlate phenotype with optical signatures, Y. 3-4 (all team)	Develop image storage searchable depository, Y.5 (all team with CI team)
Define in detail sensor & data specifications for field robots, March 2015 (DeSouza)	Field robots deployed and data collected	Field robots deployed and data collected	Field robots deployed and data collected	Field robots deployed and data collected
Complete design and construction of the AGV, March 2015. Obtain data from at least 50 plants, July 2015 (DeSouza)	AGV deployed and data collected	Working ecosystem model, July 2017 (Holdo)	AGV deployed and data collected and data analyzed	Data from AGV analyzed
Generate seed resources for field & conservation environment screening, May 2015 (Fritschi, Mockler, Topp)	Hypespectral/optical/thermal imaging tools field operational, June 2016 (Holdo, Fritschi, DeSouza, Berezin, Yin)	Hypespectral/optical/thermal imaging tools used in field research	Hypespectral/optical/thermal imaging tools used in field research and data analyzed	Analyze data
Deploy fixed cameras in the field and obtain data from several hundred plants, July 2015 (Pless, Mockler, Fritchsi)	Deploy fixed cameras in the field and obtain data from several hundred plants, July 2016 (Pless, Mockler, Fritchsi)	Deploy fixed cameras in the field and obtain data from several hundred plants, July 2017 (Pless, Mockler, Fritchsi)	Deploy fixed cameras in the field and obtain data from several hundred plants, July 2018 (Pless, Mockler, Fritchsi)	

Identify the most promising genetic population for 2016/17 field trials and CE, Dec 2015 (Fritschi, Mockler, Topp)	Phenotyping: 1st field trial complete & C.E., Nov. 2016 (all team)	Phenotyping: 2nd field trial complete & C.E., Nov. 2017 (all team)	Field & CE: Begin advanced gene mapping & identification. Detailed studies including transcriptomics, --> field trial 3 as contingency, Nov. 2018 (Mockler, Fritschi, Topp)	
Develop UAS technology platform for field data acquisition, Dec. 2015 (Burken)	Use remote sensing datasets to analyze large scale vegetation change for both crops & native species under climate stress conditions, Dec. 2016 (Burken)	Link or correlate specific plant imaging datasets at the single plant level to large field & regional data sets, Dec. 2017 (Burken)	Analyze data	Genes & QTL identified for functional studies & breeding, 2019 (Mockler, Fritschi, Topp)
Produce processed images and initial 3D models of plants, leaves, branches, etc., Dec. 2015 (De Souza)	Incorporate new sensors into AGV & UAS; collect field data; image processing and modeling, 2016 (DeSouza)	Automate UAS & AGV navigation; collect field data; data processing; phenotypic/genotypic correlations, 2017 (DeSouza)	Complete system (UAV & AGV) automation; collect field data; data processing; phenotypic/genotypic correlations, 2018 (DeSouza)	Field data collection; trait correlation; suggest new sensors and data modalities, 2019 (DeSouza)
COMMUNITY TEAM				
Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Archival Sources identified & collected (all team)	Inventory & survey instruments complete (all team)	Community-focused historical research agendas established (Hurley)	Completed park manager survey & interviews (Wilhelm Stanis & Morgan)	Community planning documents completed (all team)
Community Commons established (Dabson)	Priority communities & parks identified (all team)	Completed park visitor survey and interviews (Morgan & Wilhelm Stanis)	Complete community resilience in X communities (Dabson)	Completed facilitated workshops (all team)
Resilience indicators identified (Dabson)	Land management practices identified (Navarrete-Tindall, Pierce, Nilon)	Land owner/manager survey complete (Navarrete-Tindall, Pierce, Nilon)	Completed land management scenarios (Navarrete-Tindall, Pierce, Nilon)	Publications and reports (all team)
Stakeholders identified (Navarrete-Tindall, Pierce, Nilon)	Virtual City visualization completed (Hurley)			
CI TEAM				
Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Database programmer analyst hired	CI grad students trained	Seamless integration of data between teams		X undergrad students trained, Y5 (all team)
Machine learning graduate student hired	Train education team in CI resources			
Schedule for equipment acquisition determined	Acquire & deploy additional equipment	Provide support for ongoing CI needs	Provide support for ongoing CI needs	X women trained in computing, Y5 (all team)
Collaborate on LU course design	Collaborate on computational modules for physically disabled students	Train additional CI students	Train additional CI students	Train additional CI students
Collaborate on computational modules for Women's Institute	Create public portal for MO DIRT	Maintain public portal for MO DIRT	Maintain public portal for MO DIRT	Maintain public portal for MO DIRT
Complete Drupal portals for reporting and statewide committee	Roadmap for research interactions with other teams			X disabled students trained in bioinformatics, Y5 (all team)
Complete Phase 1 of public website	Complete Phase 2 of public website	Complete Phase 3 of public website		X students & researchers trained in data management, Y5 (all team)
Computing system architectural plan	Identification of existing ontologies and development of new ones completed			
	Analysis of data types and formats for public and outreach needs completed			
Portal: Education Data backup plan implemented	Portal: Research data Data transfer procedures developed and implemented			
Radar connected to internet	Data management survey completed and evaluated			
	Develop & explain/tutorial best practices of data management			
	Evaluate data management plans submitted by research groups			

	Sample data collected			
	Analysis of integration needs completed	Data schema implemented		
	Parallel classifier prototype completed	Parallel classifier implementation working	Parallel classifier feature completed	Parallel classifier roll-out
	Working prototype for sparse learning package	Sparse learning package working on initial data sets	Sparse learning package feature completed	Release sparse learning framework as open source
		Publication of large scale sparse learning algorithms		

SCIENCE EDUCATION & OUTREACH TEAM				
Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Modules & Workshops. Audience: K-12 (formal & non-formal): Needs assessment instrumentation designed and data collection begun (Sadler/Waldron)	Modules & Workshops. Audience: K-12 (formal & non-formal): Needs assessment complete (Sadler/Waldron)			Modules & Workshops. Audience: K-12 (formal & nonformal): Summative eval of learning complete (Mod. & PD)
Modules & Workshops. Audience: K-12 (formal & nonformal): 2 modules are online & PD conducted (Sadler, White, Woodford-Thomas)	Modules & Workshops. Audience: K-12 (formal & nonformal): 2 additional modules are developed, prototyped and PD conducted	Modules & Workshops. Audience: K-12 (formal & nonformal): 2 additional modules are developed, prototyped and PD conducted	Modules & Workshops. Audience: K-12 (formal & nonformal): 2 additional modules are developed, prototyped and PD conducted	Modules & Workshops. Audience: K-12 (formal & nonformal): 8 learning modules are online & PD conducted (Sadler, White, Woodford-Thomas
MO DIRT. Audience: general public (youth & adults): MO DIRT tools & kits & website are developed (White, Woodford-Thomas)	MO DIRT. Audience: general public (youth & adults): MO DIRT participants are recruited/trained for data collection (all team)	MO DIRT. Audience: general public (youth & adults): Data deposition to website and analyses begin; QA/QC data to researchers, Public Access for teaching purposes (Woodford-Thomas, White, Sci & CI teams)	MO DIRT. Audience: general public (youth & adults): Data collection and analyses continue; public sharing	MO DIRT. Audience: general public (youth & adults): MO DIRT. Audience: general public (youth & adults): Evaluation of MO DIRT complete
SLSC Exhibit. Audience: general public (youth & adults): Exhibit design complete (SLSC group)	SLSC Exhibit. Audience: general public (youth & adults): Exhibit open (SLSC group)	SLSC Exhibit. Audience: general public (youth & adults): Interpretation of MO EPSCoR research	SLSC Exhibit. Audience: general public (youth & adults): Updates to SLSC exhibit complete (SLSC group)	SLSC Exhibit. Audience: general public (youth & adults): Evaluation of SLSC exhibit complete (Encarnacion team)
Women's Summer Comp. Sci. Inst. Audience: women. Women's CS Inst. @ Danforth complete (Woodford-Thomas, Plant team, Climate team, CI team)	Women's Summer Comp. Sci. Inst. Audience: women. Women's CS Inst. @ Mizzou complete (Woodford-Thomas, Plant team, Climate team, CI team)	Women's Summer Comp. Sci. Inst. Audience: women. Women's CS Inst. @ WUSTL/SLU complete (Woodford-Thomas, Plant team, Climate team, CI team)	Women's Summer Comp. Sci. Inst. Audience: women. Women's Summer Comp. Sci. Inst. MST/UMKC complete (Woodford-Thomas, CI and research teams)	Women's Summer Comp. Sci. Inst. Audience: women. Evaluation of all CS Institutes (CI team and Heise)
Coursework in Computer Sci. Audience: undergrads @ LU: LU undergrad course in CS (comp. intell. & undergrad research sem.). Offered, Y1-2 (LU group). 4 students (target) are in internships, Y1-3 (LU group)	Coursework in Computer Sci. Audience: undergraduates @ LU. Internships continue (target 4/year) (LU group)	Coursework in Computer Sci. Audience: undergraduates @ LU. Computer science course is made available to students at other Transect sites, Internships continue (target 4/year) (LU group, CI team)	Coursework in Computer Sci. Audience: undergraduates @ LU; Internships continue (target 6/year)	Coursework in Computer Sci. Audience: undergraduates @ LU. Evaluation of course impact internships & workforce training (CI team and Heise)
Comp. Sci Internships for UR Sts. Audience: undergrad students w/disabilities. Review of Voc. Rehab resources complete (Gray)	Comp. Sci Internships for UR Sts. Audience: undergrad students w/disabilities. Spinal cord injury (SCI) students recruited w/VR counselor (Gray)	Comp. Sci Internships for UR Sts. Audience: undergrad students w/disabilities. Students work with Climate, Plant, Community, and CI teams.	Comp. Sci Internships for UR Sts. Audience: undergrad students w/disabilities. Students work with Climate, Plant, Community, and CI teams.	Comp. Sci Internships for UR Sts. Audience: undergrad students w/disabilities. Evaluation of course impact internships & workforce training (Gray and team)

Appendix C. Accomplishments

Team	Aim #	Accomplishment	Climate	Plant	Community	CI	Education
Climate	Aim 1	Improved spatial hydrological modeling (Hubbart)					
	Aims 1 & 2	Create more reliable seasonal outlooks of temperature/precipitation (Lupo/Guinan/Market/Travlos)					
	Aim 2	Improved estimates of decadal-scale precipitation across all four seasons (Eichler/Adegoke)					
	Aim 3	Improved understanding of climate change on wetland biogeochemistry and wetland/plant communities (Goyne/Webb)					
	Aim 4	Establish uncertainty in future changes in Missouri hydroclimate (Svoma)					
Plant	Aim 1	Genes and QTL identified for functional studies and breeding					
	Aim 2	Unmanned aerial systems (UAS) and autonomous ground vehicles (AGV) platforms developed and deployed for crop and ecosystem remote sensing					
	Aims 1, 2 & 3	Optical signatures of plants defined and correlated with stress phenotypes					
	Aims 3 & 4	Computational algorithms, software, pipelines, and database for acquiring and processing, manipulating and mining phenomics imaging data developed and deployed					
	Aim 4	Mechanistic understanding of response of native prairie plant communities to altered precipitation regimes					
Community	Aims 1, 2, 3 & 4	Broader understanding and discussion around climate change, community impacts, and adaptation					
	Aim 1	Improved ability/capacity of communities to engage in research /analysis					
	Aim 2	Developed tools and methods (e.g. survey instruments, websites, etc.) to support (b) and share broadly					
	Aim 3 & 4	Improved planning and decision making process by stakeholders					
CI	Aim 1 & 2	Seamless integration of data across teams					
	Aim 1, 2 & 4	Computational resources available for all teams, including training resources					
	Aim 2	Predictive models, algorithms, analyses developed & deployed					
	Aim 3	Trained X students in data management, analysis, including underrepresented students					
	Aim 4	Data portal/system, access and outreach to the public					
Education	Aim 1, 2 & 3	Missourians and others are more informed and engaged in climate and plant studies					
	Aim 2	Citizen science engages youth and adults into research pipelines					
	Aim 2 & 3	Community-based partnerships are increased					
	Aim 4 & 5	Interest and opportunities are fostered, bridging the natural sciences and computer sciences					
	Aim 4 & 5	Workforce development of underrepresented sectors in STEM and computer science careers					

Appendix D. List of Participants

Team	Name	Role	Institution	Email
Administration	John C. Walker	PI/PD	UMC	walker@missouri.edu
	Anna Waldron	Associate PD	UMC	waldrona@missouri.edu
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	Pat Guinan	Co-Investigator	UMC	guinanp@missouri.edu
	Bo Svoma	Co-Investigator	UMC	svomab@missouri.edu
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	Anthony Lupo	Co-Investigator	UMC	lupoa@missouri.edu
	John Travlos	Co-Investigator	UMC	travlosj@missouri.edu
	Lisa Webb	Co-Investigator	UMC	webbli@missouri.edu
Plant	Todd Mockler	Co-PI/Leader	DDPSC	tmockler@danforthcenter.org
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	Mikhail Berezin	Co-Investigator	WUSTL	berezinm@mir.wustl.edu
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	Robert Pierce	Co-Investigator	UMC	piercer@missouri.edu
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	Troy Sadler	Co-Investigator	UMC	sadlert@missouri.edu
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