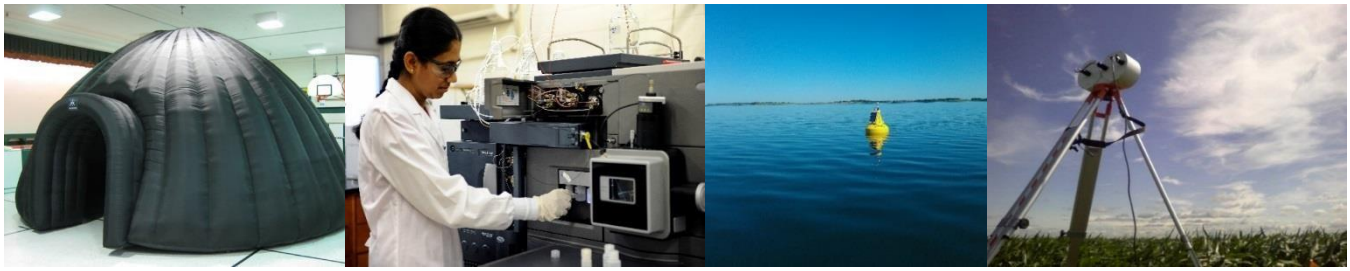

Innovative and **S**trategic **P**rogram **I**nitiatives for **R**esearch and **E**ducation-**N**orth **D**akota
INSPIRE North Dakota

NSF EPSCoR RII Track-1 Strategic Plan 2014-2019

OFFICIAL START DATE: August 1, 2014 **EXPIRATION DATE:** July 31, 2019
AWARD NUMBER: IIA-1355466

REVISED (November 16, 2016): following September 9, 2016, acceptance of March 17, 2016 NSF Reverse Site Visit Panel Recommendations Response

ND EPSCoR
Experimental Program to Stimulate Competitive Research

List of Major Strategic Plan Revisions approved by NSF during March 2016 Reverse Site Visit (RSV):

Changes made in response to RSV recommendations:

- RSV Recommendation #1 - *Develop a plan for improving the [Track-1] project's external communications, including traditional media engagement, social media, and web presence*
    - An Action Plan was developed *(see Appendix 4.4*) and 2 senior personnel, with backgrounds in communication science, were added to the project
        - CRCS - Crystal Alberts (Associate Professor and Director of Writers Conference, UND)
        - CSMS - Zoltan Majdik (Associate Professor, Communication, NDSU)
- RSV Recommendation #2 - *Specify a set of specific objectives for improving the project's external collaborators and partnerships*
    - An Action Plan was developed *(see Appendix 4.4*)
- RSV Recommendation #3 – *Develop a plan to further facilitate cross-institutional ties for each of the two centers, with a specific focus on sustainable collaborations beyond the project's scope*
    - 2 senior personnel with ties to the TCs and PUIs were added to the project *)*
        - CRCS - Erin Gillam (Associate Professor, Biological Sciences, NDSU)
        - CSMS - Alena Kubatova (Professor, Department of Chemistry, UND)
- RSV Recommendation #4 - *Adjust the Centers' vision and goals to provide a more inclusive environment for projects like those being established at the TCs and PUIs to provide a clearer basis for evaluating whether similar future efforts are consistent with CSMS' and CRCS' goals*
    - Language as adding to both centers' vision and goal statements

Changes in Committee memberships

- ND EPSCoR Steering Committee
    - Barry Milavetz replaced by Grant McGimpsey
    - Jennifer Janecek-Hartman replaced by Twyla Baker-Demaray
    - Vacant PUI position filled by Andre DeLorme
- ND EPSCoR Advisory Board
    - Joe Kroeber replaced by Lois Delmore
    - Barry Milavetz replaced by Grant McGimpsey
    - Vacant Governor's Office position filled by Kayla Effertz, who has since left the Governor's Office
    - Vacant ND University System Chancellor's representative position filled by Richard Rothaus
    - 1 of 2 vacant regional industry representative positions filled by Thomas D. Shorma
- External Advisory Board
    - Kathryn Uhrich agreed to Chair the EAB
    - William Collins replaced by Yannick Huot
    - Daniella Scalice replaced by Hedi Baxter Lauffer, who was subsequently replaced by Diana Dalbotten
    - Vacant Commerce representative position filled by Chris Kalash

Changes in Participants

- Loss of 4 senior personnel
  - 8/15/15: Andrei Kirilenko (CRCS researcher) left UND
    - CRCS and the UND campus continue to work on management plan related to this work
  - 8/27/15: Erika Offerdahl (Education and Workforce Development Co-Lead) left NDSU
    - NSF approval was obtained to add James Nyachwaya was added as an Education and Workforce Development Co-Lead for the bridging students from high school to college and to coordinate the project's REU program
  - 10/26/15: Gretchen Mullendore (CRCS researcher and Education and Workforce Development Co-Lead) left the project.
    - NSF approval was obtained to add CRCS researcher: Aaron Kennedy as his replacement.
    - CRCS researcher, Cindy Juntunen, already an Education and Workforce Development team member, assumed the role of Co-Lead for the K-12 portion of the project and Ashley Hutchison was added to the Team to assist with those efforts.
  - 6/30/16: Bret Chisholm (CSMS researcher left NDSU).
    - NSF approval was obtained to add CSMS Andriy Voronov as his replacement
- 2 of the 4 new CSMS researchers have been hired
  - Alexander Parent (Assistant Professor, Chemistry, NDSU)
  - Mohiuddin Quadir (Assistant Professor, Coatings & Polymeric Materials, NDSU)
  - Continuing to recruit 2 new hires in: 1) Computational Polymer Science and 2) Life Cycle Assessment
- All 5 Tribal College presidents named faculty researcher participants
  - CCCC: Brent Voels (Instructor, Science) joined CRCS
  - NHSC: Kerry Hartman (Academic Dean and Chair, Sciences) joined CRCS
  - SBC: Mafany Ndiva Mongoh (Instructor, Ag/Science) joined CSMS
  - TMCC: Audrey LaVallie (who has since left TMCC) joined CSMS and Stacie Blue (TCUP Environmental Science Instructor joined CRCS
  - UTTC: Mandy Guinn (Instructor, Science) joined CRCS
- All 4 Primarily Undergraduate Institution (PUI) had seven faculty researcher participants successfully compete for a Track-1 seed award
  - DSU: PI - Eric Brevik (Professor of Geology and Soils and Chair, Department of Natural Sciences); Co-PI - Paul Barnhart (Assistant Professor of Biology, Department of Natural Sciences); and Co-PI - Joshua Steffan (Assistant Professor, Department of Natural Sciences) joined CRCS
  - MaSU: PI - Mikhail Bobylev (Professor, Science – Chemistry) joined CSMS
    MiSU: PI - Khwaja Hossain (Associate Professor, Science and Mathematics) joined CSMS
  - VCSU: PI - Andre DeLorme (Professor and Chair, Department of Science) and Co-PI - Casey Williams (Assistant Professor, Department of Science) joined CRCS
- Tribal Colleges Liaison Manager, Scott Hanson, was hired
- CSMS Project Assistant, Kathleen Wahlberg, was hired

Metric changes

- Reporting of Year 1 and Year 2 (through January 31, 2016) Progress Toward the Metrics
- Metrics Changes approved by NSF RSV panel have been incorporated
- Mitigation Plans, approved by the NSF RSV Panel, for Metrics that were reported as being "Behind Schedule" during the RSV follow each metric table

LEADERSHIP, STEERING COMMITTEE AND PROJECT EXTERNAL ADVISORY BOARD

INSPIRE-ND Principal Investigators:

- **Dr. Kelly A. Rusch**, Project Director and Principal Investigator, NDSU
- **Dr. Mark Hoffmann**, Associate Project Director and Co-Principal Investigator, UND
- **Dr. Jean Ostrom-Blonigen**, Project Administrator and Co-Principal Investigator, NDSU

ND EPSCoR Steering Committee:

- **Dr. Grant McGimpsey,** ND EPSCoR State Steering Committee **Chair** and Vice President for Research and Economic Development, UND
- **Dr. Twyla Baker-Demaray**, President, Nueta Hidatsa Sahnish College
- **Dr. Malcolm G. Butler**, Professor, Biological Sciences, NDSU
- **Dr. Andre DeLorme**, Professor and Chair, Department of Science, Valley City State University
- **Dr. Jonathan D. Geiger**, Professor and Chair, Pharmacology, Physiology and Therapeutics, UND
- **Dr. Gary Goreham**, Professor, Sociology, NDSU
- **Dr. Mark R. Hoffmann**, ND EPSCoR Associate Project Director and Associate Vice President for Research and Economic Development, UND, ex-officio
- **Dr. Kalpana Katti**, Professor and Distinguished Professor Civil Engineering, NDSU
- **Dr. Evguenii Kozliak**, Professor, Chemistry, UND
- **Dr. Jean Ostrom-Blonigen**, ND EPSCoR Project Administrator, NDSU, ex-officio
- **Dr. Michael Poellot**, Professor and Chair, Atmospheric Sciences, UND
- **Dr. Kelly A. Rusch**, P.E., ND EPSCoR Project Director, Vice President, Research and Creative Activity, NDSU, ex-officio

ND EPSCoR Advisory Board:

- **Representative Lois Delmore**, Grand Forks
- **Representative Kathy Hawken,** Fargo
- **Dr. Mark R. Hoffmann**, ND EPSCoR Associate Project Director and Associate Vice President for Research and Economic Development, UND, ex-officio
- **Senator Raymon Holmberg**, Grand Forks
- **Dr. Grant McGimpsey,** ND EPSCoR State Steering Committee Chair and Vice President for Research and Economic Development, UND, ex-officio
- **Dr. Jean Ostrom-Blonigen**, ND EPSCoR Project Administrator, NDSU, ex-officio
- **Dr. Richard Rothaus**, Interim Vice Chancellor of Academic and Student Affairs, North Dakota University System, Bismarck
- **Dr. Kelly A. Rusch**, P.E., ND EPSCoR Project Director, Vice President, Research and Creative Activity, NDSU, ex-officio
- **Senator Mac Schneider,** Grand Forks
- **Mr. Thomas D. Shorma,** CEO/President, WCCO Belting, Inc., Wahpeton
- **Dr. Laurel Vermillion,** President, Sitting Bull College
- **TBA,** ND Governor's representative
- **TBA,** One additional representative from regional industry

External Advisory Board:

- **Dr. Kathryn Uhrich**, **EAB Chair** and Dean, College of Natural and Agricultural Sciences, University of California - Riverside
- **Ms. Ann Marie Chischilly**, Executive Director, Institute for Tribal Environmental Professionals, Northern Arizona University
- **Dr. Diana Dalbotten**, Program Director for REU on Sustainable Land and Water Resources and Director of Diversity and Broader Impacts for the St. Anthony Falls Laboratory (University of Minnesota) and for the National Center for Earth-surface Dynamics
- **Mr. Christopher Kalash**, Commercialization Manager, North Dakota Department of Commerce, Bismarck
- **Dr. James Kenar**, Research Chemist, United States Department of Agriculture, Agricultural Research Service, Peoria
- **Dr. Sonia Kreidenweis,** Professor, Department of Atmospheric Science, Colorado State University
- **Dr. Amy Landis**, Professor/Endowed Chair, Glenn Department of Civil Engineering and Director, Institute for Sustainability, Clemson University
- **Dr. Yannick Huot**, Associate Professor, Applied Geomatics Department, University of Sherbrooke

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Table 1. Glossary of Acronyms

CCCC	Cankdeska Cikana Community College, Fort Totten, ND
CI	Cyberinfrastructure
CRCS	Center for Regional Climate Studies
CSMS	Center for Sustainable Materials Science
DoE	Department of Energy
DSU	Dickinson State University, Dickinson, ND
EMPOWERED-ND	Emerging Programs for Workforce Development, Outreach, Education and Diversity-ND
GCM	Global Climate Model
GLDAS	Global Land Data Assimilation Systems
HPC	High Performance Computing
IHM	Integrated Hydrological Modeling
INSPIRE-ND	Innovative and Strategic Program Initiatives for Research and Education-ND
InVEST	Integrated Valuation of Ecosystem Services and Trade-offs
LLISST-VSF	Laser In Situ Scattering and Transmissometry - Volume Scattering Function
MaSU	Mayville State University, Mayville, ND
MiSU	Minot State University, Minot, ND
MODIS	Moderate Resolution Imaging Spectroradiometer
NATURE	Nurturing American Tribal Undergraduate Research and Education
NDSCS	North Dakota State College of Science, Wahpeton, ND
NDSU	North Dakota State University, Fargo, ND
NHSC	Nueta Hidatsa Sahnish College (formerly Fort Berthold Community College), New Town, ND
PRISM	Portable Remote Imaging Spectrometer
PUIs	Primary Undergraduate Institutions
REU	Research Experience for Undergraduates
RII	Research Infrastructure Improvement
SA	Sunday Academy
SBC	Sitting Bull College, Fort Yates, ND
SBIR	Small Business Innovation and Research
STTR	Small Business Technology Transfer
SWAT	Soil and Water Assessment Tool
TCs	Tribal Colleges
TMCC	Turtle Mountain Community College, Belcourt, ND
UND	University of North Dakota, Grand Forks, ND
USDA	United States Department of Agriculture
UTTC	United Tribes Technical College, Bismarck, ND
VSCU	Valley City State University, Valley City, ND

1. EXECUTIVE SUMMARY

1.1 Introduction

North Dakota (ND) EPSCoR's Strategic Plan details the conceptual, programmatic and management framework for successfully accomplishing the goals of **In**novative and **S**trategic **P**rogram **I**nitiatives for **R**esearch and **E**ducation-**N**orth **D**akota (**INSPIRE-ND)** set forth in North Dakota's NSF EPSCoR Track I award IIA-1355466 [2014-2019]. Through INSPIRE-ND, the state's two research universities, North Dakota State University (NDSU) and the University of North Dakota (UND), will lead a dually-focused research effort that capitalizes on the growing research capabilities of the state's Tribal Colleges (TCs) and the Primarily Undergraduate Institutions (PUIs).

Regional climate change and sustainable materials directly impact North Dakota's traditionally strongest economic sector, agriculture. With diverse crops, ND is a national leader in the production of all dry edible beans, navy beans, pinto beans, canola, flaxseed, honey, durum wheat, spring wheat, barley, lentils, oats, dry edible peas, sunflowers, and all other wheat production[1]. INSPIRE-ND examines the effects of climate change on the production of food [systems, supply and protein density] and biofeedstock supplied to the nation and the world by the Northern Great Plains. INSPIRE-ND will demonstrate the viability of alternative biofeedstock sources that are low cost and renewable, with long product lifetimes, high durability, offer efficient recyclability and high value to discover new sustainable materials that will influence ND's economy by strengthening its overall competitiveness. INSPIRE-ND is designed to build and sustain a transformative, multifaceted, synergistic academic research and education enterprise, anchored by a more diverse skilled workforce to drive ND's emerging knowledge-driven economy. With these outcomes in mind, the program will: 1) develop two new research themes/platforms in regional climate studies and sustainable material science; 2) build physical and human research infrastructure; and 3) integrate research, education and human resources with statewide workforce development initiatives to increase public scientific literacy through a coordinated initiative titled: **EMPOWERED-ND** (**EM**erging **P**r**O**grams for **W**orkforc**E** Development Out**R**each, **E**ducation and **D**iversity-**N**orth **D**akota). EMPOWERED-ND is a modern STEM workforce program aimed to build human capacity for the future use of renewable resources for chemicals, food and energy. The program will explore innovative research areas focused on bio-based materials (Center for Sustainable Materials Science (CSMS)) and coupled natural human systems driven by a changing climate (Center for Regional Climate Studies (CRCS)) while working to strengthen workforce development; expand and leverage our collaborative cyberinfrastructure environment; provide primary as well as seed funding for emerging high impact and transformative research; further encourage the diversity of our programs; and partner and collaborate with private, state and federal entities in ways that improve the long-term research competitiveness of North Dakota.

1.2 INSPIRE-ND: Vision and Mission

North Dakota is poised to continue its recent research program growth trajectory in addressing important scientific problems of agricultural global relevance through broadening participation of the Tribal Colleges and Primarily Undergraduate Institutions. Through these collaborations, North Dakota envisions building a competitive 21st century workforce equipped with the skills necessary to meet the environmental challenges of the agricultural sector. The INSPIRE-ND Strategic Plan was formulated based on the program's vision and mission articulated in the original proposal submitted to NSF in August 2013.

> **Vision:** INSPIRE-ND will help lead the nation in environmentally sustainable, agriculturally-related food production and biofeedstock development, integrated with an educated workforce necessary to meet the agricultural challenges in the face of a shifting environmental climate.
> **Mission: INSPIRE** North Dakota to address and mitigate the regional environmental threats to the state's agriculture production.

INSPIRE-ND has five strategic foci: 1) CRCS; 2) CSMS; 3) Diversity; 4) Education and Workforce Development; and 5) Partnerships, Collaborations and Communication. Cyberinfrastructure is embedded throughout each of the five strategic foci and is an enabling technology. As such, cyberinfrastructure is not considered a goal. Each focus area is associated with a strategic priority, goal(s), several objectives, numerous activities and benchmarks, key impact, team lead and participants. Team participation is from multiple institutions. The goals, objectives, benchmarks and activities are presented in easy–to-read tables to facilitate tracking and reviewing program progress by the program leads, ND EPSCoR management team, NSF Programs Directors, and external evaluation teams (including the external evaluator, the External Advisory Committee, and Reverse Site Visit panel members).

The INSPIRE-ND program was designed to promote an EMPOWERED-ND by threading activities into each of the research cluster foci in an effort designed to increase the program's long-term sustainability. To further promote diversity, education, workforce development, partnerships, collaborations and communication, interdisciplinary and inter-institutional teams of program members reviewed program plans and identified new ideas and opportunities for synergy among program components during the Strategic Planning Workshop. The five Tribal Colleges in North Dakota (Cankdeska Cikana Community College, Nueta Hidatsa Sahnish College, Sitting Bull College, Turtle Mountain Community College and United Tribes Technical College,) are important partners of INSPIRE-ND, as are the state's four PUIs (Dickinson State University, Mayville State University, Minot State University and Valley City State University).

The INSPIRE-ND Strategic Plan also includes the following programs: 1) synergies for sustainability, 2) risk mitigation, 3) management and succession plan and 4) evaluation and assessment process.

2. INTRODUCTION

2.1 Strategic Planning Process

The strategic planning process involved a logical sequence of productive meetings during August through December 2014 with the program's PI (Rusch), co-PIs (Hoffmann and Ostrom-Blonigen), previous co-PI (Anderson), ND EPSCoR Steering Committee chair (Milavetz), external evaluator (Shaw), external facilitator (CONCUR, Inc.) and program team members.

The management and program teams corresponded regularly and met in Hillsboro, ND on September 23, 2014 to review and update program benchmarks and milestones in preparation for the Strategic Planning Workshop, held on October 20-21, 2014 at NDSU, Fargo, ND. The goal of the workshop was to produce a collaborative plan for managing and measuring ND EPSCoR RII Track-1 project progress. Thirty-three participants engaged in the two-day facilitated discussion, including Dr. Timothy M. VanReken, NSF EPSCoR Program Director for North Dakota, ND EPSCoR leadership, program leads and team members, other representatives from NDSU and UND, the chair of the ND EPSCoR State Steering Committee, two members of the ND EPSCoR State Steering Committee (Dr. Kalpana Katti and Dr. Michael Poellot), one member of the North Dakota University System–representing the PUIs (Dr. Richard Rothaus), the project's external evaluator and the external facilitators. Although invited, the state Tribal College representative to the ND EPSCoR State Advisory Committee was unable to be present for the workshop.

Participants were provided with workshop information in advance that included the agenda, the proposal summary, and a list of participants. During the workshop, the 33 participants reviewed program plans; articulated outcomes and objectives, drafted and refined benchmarks and metrics; refined a program succession plan; outlined plans for program collaboration efforts; and identified program risks and mitigation approaches.

Subsequent to the workshop, group leads took on responsibility to continue to develop their respective tables: CRCS, CSMS, Diversity, Education/Workforce Development and Partnerships/ Collaborations/Communication for feedback from the ND EPSCoR leadership and the external consultant. Additionally, members of the ND EPSCoR Leadership team visited with all of the Tribal College Presidents at the November 18, 2014 ND Tribal Association Meeting to confer with them about the new award and to discuss the vacant Tribal Colleges Liaison position. The TC presidents were asked to review and provide input on the strategic plan on December 1, 2014. Although none of the TC presidents provided feedback on the strategic plan; their campuses are engaged in the Track-1 program. TC involvement as of 1/15/15 includes:

- August 2014 – Research cluster personnel and the ND EPSCoR Office visited Cankdeska Cikana Community College (CCCC). As a result of that visit, Brent Voels, Science Instructor, CCCC, has been confirmed by CCCC's president as a researcher on the Center for Regional Climate Studies (CRCS) team. Dr. Voels' research interests are oil spill impacts: soil quality, persistence of heavy metals, and crop yields and he seeks to tie his research to broader impacts on land-use.
- November 2014 - ND EPSCoR's Hoffmann and Ostrom-Blonigen attended the North Dakota Association of Tribal Colleges meeting and discussed the Track-1 initiatives, the upcoming C2 interactive video conference, and additional upcoming TC visits with all five of the TC presidents.
- November 2014 - Research cluster personnel and the ND EPSCoR Office visited Sitting Bull College (SBC). As a result of that visit, SBC faculty have expressed interest in work being done at both the CRCS and the Center for Sustainable Materials Science (CSMS). SBC faculty

are planning to meet during spring semester 2015 to determine which project their campus will bring forward. Additionally outside of immediate goals for research cluster collaboration, SBC expressed interest in working with NDSU and UND to develop partnerships in which graduate students from both campuses would work with their advisors to teach modules outside of the expertise of current faculty. [3/17/16 Update: Following their campus meeting, SBC's president confirmed that Mafany Ndiva Mongoh, Instructor, Ag/Science would serve as a researcher on the Center for Sustainable Materials Science (CSMS) team. Dr. Mongoh studies sustainable biodegradation of polymers - impact of microorganisms in the environment.]

- December 2014 - Research cluster personnel and the ND EPSCoR Office held a final C2 interactive video conference session, which was attended by four of the five TCs. During that meeting, a faculty members at Fort Berthold Community College [(FBCC) - now known as Nueta Hidatsa Sahnish College (NHSC)] and United Tribes Technical College (UTTC) expressed interest in joining research projects. Also present during this videoconference was Dr. Richard Rothaus, representing the PUIs.
- January 29-30, 2015 - Research cluster personnel and the ND EPSCoR Office will visit FBCC (now known as NHSC) and UTCC to determine which project those campuses wish to bring forward. [3/17/16 Update: As the result of a visit to their campus by research cluster and ND EPSCoR Office personnel, the NHSC president confirmed that Kerry Hartman, Academic Dean and Chair, Sciences would serve as a researcher on the CSMS team; however, as a result of further discussions, Dr. Hartman, who studies the impact of climate change on juneberry pollination and yield, joined the CRCS team. Additionally, as a result of the research cluster and ND EPSCoR Office personnel visit to UTTC, the president confirmed that Mandy Guinn, Instructor, Science, would serve as a researcher on the CRCS team. Ms. Guinn identifies bat impact on the ND agricultural economy.]
- February 2015 - The ND EPSCoR is waiting for Turtle Mountain Community College (TMCC) to respond to a request to visit that campus in February 2015. [3/17/16 Update: As a result of a visit to their campus by research cluster and ND EPSCoR Office personnel, the TMCC president confirmed that Deborah Hunter (who has since left the project for personal reasons) would join the CRCS team and Audrey LaVallie, Instructor, Chemistry, would serve as a researcher on the CSMS team. Dr. LaVallie studies the analytical aspects of biomass chemical components.]The collaborative input derived from the two-day workshop and subsequent meetings yielded the **INSPIRE-ND Strategic Plan**. This Plan outlines how ND EPSCoR will achieve its program vision, mission and goals and will be reviewed and restructured annually. [8/16/16 Update: Stacie Blue, TCUP Environmental Science Instructor, who studies water quality and plant phenology received campus endorsement to join the CRCS project when Dr. LaVallie left TMCC.

2.2 Alignment of INSPIRE-ND with the North Dakota Science and Technology Plan

The ideas for INSPIRE-ND emerged from an analysis of the State's economy as it aligns with research strengths of NDSU and UND. Selection of this set of aims was guided by a set of strategic documents including North Dakota's Science and Technology Plan (S&T), which identified five major areas of economic development: 1) advanced manufacturing, 2) energy, 3) value-added agriculture, 4) technology based business, and 5) tourism. INSPIRE-ND is directly linked to value-added agriculture and will be enhanced by the advanced manufacturing, energy and technology-based business initiatives in the State.

The North Dakota S&T Plan identified seven strategies to help drive economic development across the five areas: 1**)** focus research and development in areas that are already strengths in the state so that ND can continue to increase its competitive advantage; 2) support and expand the infrastructure for research, particularly at the two research universities; 3) support technology transfer and, where appropriate,

commercialization of inventions and innovations developed by universities; 4) foster partnerships between the private sector and research universities; 5) find ways to produce, hire, and retain more high school-level STEM teachers (a shortage occupation in the state), especially for small rural schools; 6) increase state investment in research at the institutions in the ND University System; and 7) create ways to increase awareness of the S&T capacity of the state, and to use it to develop regulatory schemes based on sound science. North Dakota's Science and Technology Plan can be found at: http://www.ndsu.edu/epscor/documents/Sci-TechStrategicPlan2-2013.pdf**.**

North Dakota's future prosperity depends on the successful, coordinated and funded implementation of activities within the stated strategies. INSPIRE-ND capitalizes on the agricultural, water (quantity/quality), energy and advanced manufacturing research strengths (4 of the 6 strengths detailed in the S&T Plan) at NDSU and UND, combined with the coordinated ND University System and Tribal College System to position the State as a national leader in environmentally sustainable, agriculturally-related food production and biofeedstock development. The State's goal to remain a top national agricultural producer: serves to foster the development of a diverse and sustainable agriculture platform with a variety of market pathways (i.e., food, renewable feedstocks for materials, energy); strengthens the need for a trained STEM workforce; and underscores the need of educating the public about the benefits of environmentally adaptable and sustainable agriculture for today's economy. This goal aligns precisely with North Dakota's Track-1 program goals for INSPIRE-ND.

2.3 Strategic Impacts

North Dakota's agricultural economy is growing; to sustain that growth, it is important to understand and predict how regional climate changes impact crop production. Additionally, due to the negative environmental impact of non-biodegradable materials on the environment, it is important to discover new ways to maximize the use of sustainable materials. North Dakota's RII Track-1 project supports researchers as they conduct innovative research on regional climate patterns and seek to identify the physical components necessary to transition away from fossil-based petrochemicals and their materials to more sustainable platforms. In conducting this program, North Dakota will demonstrate the essential linkage between research innovation and the social change required to embrace alternative energy sources. Two research centers, **Center for Regional Climate Studies (CRCS)** and **Center for Sustainable Materials Science (CSMS),** have been created to facilitate research, education, workforce development, and outreach on regional climate change effects on coupled natural human systems and the importance of sustainable materials. The project also includes the resources to hire four (4) NDSU faculty who will participate in CSMS research, graduate and undergraduate students to conduct research at both centers, and up to nine other affiliated facilities (5 TCs and 4 PUIs). The consequences associated with climate change and unsustainable materials are not unique to North Dakota. EMPOWERED-ND is aimed at increasing social awareness and future economic growth. The competitiveness of North Dakota researchers in NSF programs will increase as a result of this award.

[3/17/16 Update: Four $100,000 seed grants were awarded (one to each of the 4 ND PUIs) at the beginning of Year 2. As a result, five researchers from two PUIs joined CRCS: 1) DSU: PI Eric Brevik (Professor of Geology and Soils and Chair, Department of Natural Sciences) and Co-PIs: Paul Barnhart (Assistant Professor of Biology, Department of Natural Sciences) and Joshua Steffan (Assistant Professor, Department of Natural Sciences) study the impacts of climate on soil chemistry and bats and their feedback to the environment; and 2) VCSU: PI Andre DeLorme (Professor and Chair, Department of Science) and Co-PI Casey Williams (Assistant Professor, Department of Science) evaluate the impacts of climate on aquatic organisms and water quality. Additionally, two researchers from two PUIs joined CSMS: 1) MaSU; PI Khwaja Hossain (Associate Professor, Science and Mathematics) studies bio-based

composite synthesis using wheat bran and 2) MiSU: PI Mikhail Bobylev (Professor, Science - Chemistry) Synthesizes novel polymers from biomass using a method he recently patented.]

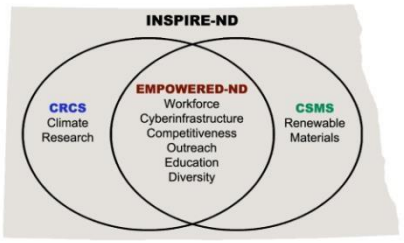
3. INSPIRE-ND Strategic Plan

3.1 Vision

INSPIRE-ND will help lead the nation in environmentally sustainable, agriculturally-related food production and biofeedstock development, integrated with an educated workforce necessary to meet the challenges in the face of a shifting environmental climate.

3.2 Mission

INSPIRE an **EMPOWERED** North Dakota: Our **In**novative and **S**trategic **P**rogram **I**nitiatives for **R**esearch and **E**ducation are building **EM**erging **P**r**O**grams for **W**orkforc**E** Development Out**R**each, **E**ducation and **D**iversity in **N**orth **D**akota to address and mitigate the regional environmental threats to the state's agriculture production.



EMPOWERED-ND is a tightly integrated workforce development, education and outreach and partnership program designed to ensure a continual pipeline of highly qualified individuals to meet the future needs of the ND economy. To encourage and sustain participation of students from underrepresented groups, EMPOWERED-ND is integrated with statewide diversity efforts.

The ND EPSCoR program will increase public scientific literacy and train a modern STEM workforce to build human capacity for future use of renewable resources for chemicals, food and energy. ND undergraduate and graduate students, as well as postdoctoral researchers, will participate in the research programs and receive mentoring for career development. Discoveries will be translated into marketable, commercial applications using strategic relationships with the private sector. Partnerships with the private sector and non-profit organizations include programs that provide students with opportunities to work with companies on technology development projects and mentoring programs for intellectual property management and technology transfer. RII elements that support underrepresented groups, especially American Indians, to pursue STEM-based careers are key features of EMPOWERED-ND. These initiatives will be accomplished via collaborations with our TCs and PUIs. EMPOWERED-ND broadens diversity of participation and builds a network of STEM advocates and stakeholders to promote new strategies for communicating the pathways and outcomes of ND EPSCoR activities. Meaningful and two-way partnerships and communication networks established from EMPOWERED-ND, and coupled with INSPIRE-ND, will foster development of the next generation of globally engaged scientists and engineers in renewable resources discovery and utilization.

3.3 Program Goals

The **overall program goals** of INSPIRE-ND are captured in the letters of the word "INSPIRE":

- **IN**novative research focused on bio-based materials and climate change
- **S**trategic integration of research, STEM education and outreach through EMPOWERD-ND to serve the entire State
- Increased workforce diversification through strategic **P**rogrammatic elements
- Increased research and technology capacity through **I**nitiatives aligned with the State's Science and Technology Plan
- Increased participation of underrepresented groups in general and in particular by research opportunities from the TCs and PUIs through engaged **R**esearch experiences

- Broader public **E**ducation on issues of sustainability and environmental stewardship through increased partnerships and communication.

3.4 Strategic Focus Areas, Goals, Objectives, Benchmarks, Metrics, Impacts, Partners, and Participants

Five focus areas of North Dakota's Track-1 project support its mission to INSPIRE an EMPOWERED North Dakota to discover new ways to care for our environment and secure the economic sustainability of our agricultural economy: 1) Center for Regional Climate Studies (CRCS); 2) Center for Sustainable Materials Science (CSMS); 3) Diversity; 4) Education and Workforce Development; and 5) Partnerships, Collaborations and Communications.

The following outline describes the organization for each of the five focus areas in the Strategic Plan:

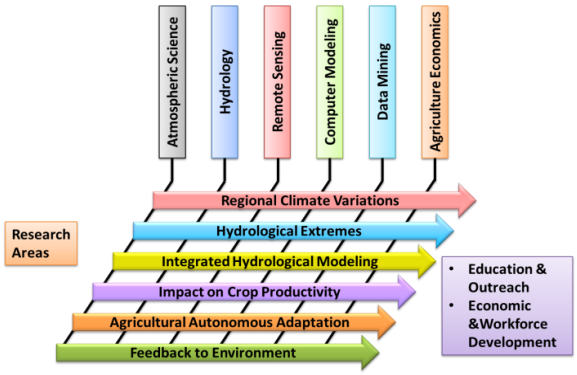
1. The focus areas are first described in a narrative format, which includes:
   - Strategic priority
   - Goals
   - Objectives to achieve goals
   - Team leads
   - Team participants and partners
   - Key outcome(s)

2. A focus area table format follows for each goal (color-coded blue), which contains:
   - Objectives for each goal (green)
   - Benchmarks/activities (gray) for each year.
     - The activity section is also highlighted (gray) in the years in which a benchmark has not started or is complete.
     - The word *"ongoing"* means that the activities of a certain year will exactly mirror the activities of the immediate prior year.

3. A separate table of Output Metrics (beige) with associated baseline and cumulative measurement targets follow each focus area table. The metrics that are highlighted (lighter beige) represent the collaboration synergy metrics (which relate to sustainability components of the program) discussed in section 3.11 of the Strategic Plan. These metrics will be used by the external evaluator to assess project progress.

3.5 Focus Area 1-Center for Regional Climate Studies (CRCS)

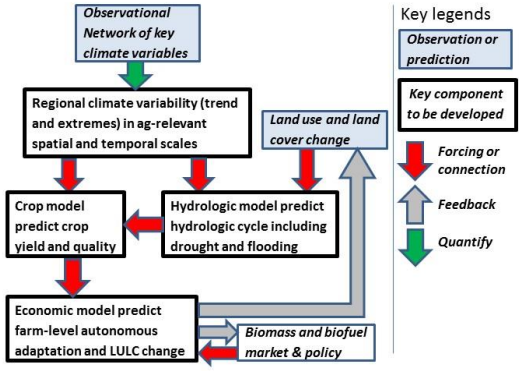
Strategic Priority: North Dakota, recognized as a major sustainable supplier of food crops and biofeedstocks, seeks to continue and advance that ranking through an increased understanding of regional climate patterns.



Goals:

1. Develop and apply an integrated modeling approach to project the impact of climate variations on the agricultural economy of the Northern Great Plains (NGP).

2. Build CRCS into a high functioning, interdisciplinary, sustainable regional climate and education center that includes utilization of cyberinfrastructure (CI).



Objectives to Achieve Goals: To achieve Goal 1, the CRCS team has identified 6 objectives with benchmark activities that are aimed to:

- Develop a comprehensive understanding of regional climate variations over the Northern Great Plains region (*objectives 1.1 and 1.2*). These climate results will provide inputs to the regional hydrological, agricultural, and atmospheric studies as mentioned in *objectives 1.3-1.6.* In addition, the team will analyze linkages between regional climate variations and extreme hydrological conditions to improve predictions of regional flooding and drought.

- Develop an integrated hydrologic modeling (IHM) system based on hydrological and meteorological databases, remote sensing observations across spatial and temporal scales (meters to 25 km, minutes to monthly), and new field data collection (*objective 1.3*). The IHM will provide varying-resolution predictions of precipitation-induced surface runoff, infiltration and ponding, subsurface flow, evapotranspiration, and stream flow. The IHM will be used to compare results for drought and flood predictions from *objectives 1.1 and 1.2* and to evaluate possible feedbacks to the hydrological cycle from climate-driven agricultural land use changes.

- Develop and demonstrate an integrated modeling approach to project the impact of climate variations on the agricultural economy in the Northern Great Plains (*objectives 1.4, 1.5 and 1.6*). This work, which demands truly collaborative efforts from multiple disciplines and has never been attempted over the study region, addresses the NSF grand challenge: "climate change prediction to advise regional adaption strategies". The team will apply both statistical- and dynamic modeling-based techniques to detailed agricultural, climate, and hydrological data to determine crop productivity (*objective 1.4*) and agricultural autonomous adaption in response to recent climate trends (*objectives 1.5*). Together these objectives will link environmental, agricultural, economic, and behavioral models to create an integrated modeling system. Further integration will occur through exploratory modeling efforts to investigate possible feedbacks of land use changes from agricultural adaptation on cloud formation and water resource quality (*objective 1.6*).

Goal 2 will be achieved by completing four objectives with benchmark activities that are aimed to:

- Create a sustainable and collaborative infrastructure (human, computational, and instrumental) for regional climate studies. This project integrates previously isolated research activities in ND and enables us, for the first time, to tackle this interdisciplinary research topic that is significant to regional agricultural-based economy and policy making. *Objective 2.1* aims to facilitate a collaborative and integrated effort among group members from more than 7 different disciplines at UND, NDSU, PUIs and TCs. Researchers from the two research universities, UND and NDSU, provide core expertise in agricultural economics, atmospheric science, computer science, hydrology, and vocational psychology. New team members from the PUIs and TCs will add more diverse geographical and cultural perspectives, while strengthening research efforts at these institutions and collaborations between institutions.

- Develop robust cyberinfrastructure necessary to support information exchange and collaborative research activities within the Center. To assist CRCS team members, located across the state, in growing, curating, processing, and sharing large climate, agriculture, and other datasets the CI team will develop/upgrade associated cyberinfrastructure, including possible enhancement to High Performance Computing (HPC) file systems *(objective 2.4)*, implementation of the Globus Online GridFTP data transfer tool (*objective 2.2*), installation of a Relational Database Management System minicloud (*objective 2.3*), and possible enhancement to the HPC modeling and simulation capabilities (*objective 2.4*).

Team Leads: CRCS Director, **Jianglong Zhang** (Associate Professor, Atmospheric Sciences, UND), is an expert in satellite remote sensing of atmospheric aerosols and data assimilation. The CRCS co-Lead, **Frank Bowman** (Associate Professor, Chemical Engineering, UND), studies atmospheric aerosols and also conducts research on assessment of K-12 STEM outreach.

Team Participants and Partners:

- **Crystal Alberts** (Associate Professor, English and Director of Writers Conference, UND) communicates the science of the center.
- **Paul Barnhart** (Assistant Professor of Biology, Department of Natural Sciences, DSU) studies the impacts of climate on soil chemistry and bats and their feedback to the environment.
- **Stacie Blue** (TCUP Environmental Science Instructor, TMCC) studies water quality and plant phenology
- **Eric Brevik** (Professor of Geology and Soils and Chair, Department of Natural Sciences, DSU) studies the impacts of climate on soil chemistry and bats and their feedback to the environment.
- **Xuefeng Chu** (Associate Professor, Civil and Environmental Engineering, NDSU) carries out research on the measurement and modeling of multi-scale watershed hydrology and topography.
- **Andre DeLorme** (Professor and Chair, Department of Science, VCSU) evaluates impacts of climate on aquatic organisms and water quality.
- **Anne Denton** (Associate Professor, Computer Science, NDSU) is an expert in data mining of complex environmental and agricultural data sets.
- **Erin Gillam** (Associate Professor, Biological Sciences, NDSU) researches the behavioral ecology of mammals in the Great Plains, with a focus on bats.
- **Mandy Guinn** (Instructor, Science, UTTC) identifies bat impacts on the agricultural economy.
- **Kerry Hartman** (Academic Dean and Chair, Sciences, NHSC) studies impact of climate change on juneberry pollination and yield.

- **Cindy Juntunen** (Interim Dean and Professor, Counseling, UND) studies vocational psychology of rural and underrepresented groups.
- **Aaron Kennedy** (Assistant Professor, Atmospheric Sciences, UND) performs numerical modeling of convective cloud dynamics and leads initiatives on climate change.
- **David Roberts** (Assistant Professor, Agribusiness and Applied Economics, NDSU) conducts econometric analysis on the impacts of agricultural production methods on environmental resources.
- **Joshua Steffan** (Assistant Professor, Department of Natural Sciences, DSU) studies the impacts of climate on soil chemistry and bats and their feedback to the environment.
- **Brent Voels** (Instructor, Science, CCCC) studies impact of oil spill impacts on ag-economy
- **Casey Williams** (Assistant Professor, Department of Science, VCSU) evaluates impacts of climate on aquatic organisms and water quality.
- **Xiaodong Zhang** (Associate Professor, Earth System Science and Policy, UND) leads research efforts on radiative and water fluxes from surface waters and land.
- **Haochi Zheng** (Assistant Professor, Earth System Science and Policy, UND) studies environmental and natural resource economics.
- Research center members will leverage and interact with all other program components, PUIs, TCs, businesses, local and national media, other potential research partners and governmental agencies.

Key outcome(s): Increased statewide physical, human and research assets to further the understanding of regional climate variations on the agricultural economy of the Northern Great Plains.

Table 2. Focus Area 1 Goals, Objectives, Benchmarks and Activities, Output Metrics and Baseline and 5-year Targets

Goal 1: Develop and apply an integrated modeling approach to project the impact of climate variations on the agricultural economy of the Northern Great Plains (NGP).					
Benchmarks/ Activities	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**
Objective 1.1: Analyze regional climate variations and data uncertainty. **(Chu/Hartman//Kennedy/ J. Zhang/X. Zhang)**					
Perform statistical and dynamical downscaling of Coupled Model Intercomparison Project Phase 5 (CMIP5) ensemble.	Acquire regional climate data from CMIP5. Test different methods for statistical and dynamic downscaling (case study).	Apply downscaling on a limited set of data: Test multiple downscaling methods with one CMIP5 GCM. Inter-compare downscaling for one GCM.	Apply down-scaling to the full dataset (~20 GCMs) and intercompare the results. Inter-compare downscaling for the entire dataset.	Use the results to inform sensitivity testing and adaptation studies.	Continue utilizing results for continuing climate studies.
Conduct observational based regional climate studies.	Acquire observational based climate data - both satellite and regional surface observation.	Conduct the studies for selected parameters, including short- and long-wave radiation, temperature and precipitation.	Conduct observational based regional climate studies to the full dataset. Inter-compare with CMIP5 based studies.	Integrate into the CMIP5 based studies.	Continue integration into the CMIP5 studies.
Make new observations of evapotranspiration (ET).	Set up instruments (scintillometer).	Collect scintillometer measurements for estimating ET.	Ongoing. Compare data with MODIS-ET estimates.	Collect data. Compare data with the IHM model prediction (1.3).	Evaluate needs for additional data.
Objective 1.2: Predict hydrological changes for extreme conditions. **(Chu/J. Zhang/X. Zhang)**					
Identify linkages between climate extremes and large-scale dynamics.	Identify historical extreme drought and flood cases over the NGP study region.	Study potential linkages to Atlantic Multidecadal Oscillations and Pacific Decadal Oscillation	Study potential linkages to other larger scale atmospheric oscillations.		
Estimate effects of climate and land use change on flood potential in Devils Lake watershed.	Test model runs for sample scenarios.	Construct CMIP5 statistical ensemble of GCM projections own-scaled for the Devils Lake watershed.	Study linkage between regional climate change, land use change and flood potential in Devils Lake watershed.	Investigate linkages in relation to flood mitigation practices.	Explore linkages in relation to mitigation and adaptation practices.

Develop a prognostic model for regional drought prediction.	Collect data (e.g. soil moisture, precipitation and ET) from GLDAS, PRISM and MODIS.	Collect data from GLDAS, PRISM and MODIS. Develop time series model for surface soil moisture.	Collect data from GLDAS, PRISM and MODIS. Develop time series model for surface soil moisture.	Validate new time series model with IHM model (1.3).	Validate new time series model with historical drought events.
Objective 1.3: Analyze regional climate variations and data uncertainty. (**Chu/Denton/X. Zhang/DeLorme/ Williams**)					
Develop, calibrate and validate an improved integrated hydrologic (IHM) model.	Plan for development, calibration and validation; review local and regional scales.	Develop a new algorithm for topographic delineation and modeling.	Develop improved algorithms for IHM model; calibrate and validate at regional and local scales	Develop a new integrated hydrologic model; calibrate and validate IHM at regional and local scales.	Calibrate and validate IHM at regional and local scales.
Collect precipitation and hydrologic data.	Select site and setup equipment (wireless gauges and sensors).	Collect precipitation (rainfall and snow) data.	Collect data (precipitation, stream/lake, and soil moisture data).	Collect, process and analyze precipitation, stream/lake, and soil moisture data.	Data processing and analysis.
Study impact of hydrology on agricultural variables.			Demonstrate data mining proof of concept model that uses hydrology output.	Establish relationship between hydrology explicit models and models that use elevation as proxy.	Complete model based on hydrology output.
Objective 1.4: Determine crop productivity response to climate change. **(Denton/Hartman/Z. Zhang)**					
Perform dynamic modeling of crop productivity response with ALMANACH software	Review updating ALMANACH software to latest version	Start the agriculture part when the climate study is at least 60percent complete	Demonstrate proof of concept of dynamic modeling of crop productivity response.	Integrate multiple GCMs; identify scenarios of crop change.	Perform model simulations; analyze results; formulate adaptation options based on simulation results.
Apply large data statistical methods to identify yield response of major crops in the NGP.	Identify preferable aggregation of precipitation data.	Determine preprocessing of precipitation data.	Use climate modeling output in data mining models to extrapolate yield response to future years.		

Use multiple resolutions to build more specific statistical models using dynamic modeling.	Develop proof of concept for window-based techniques using massively available data, in particular elevation and satellite imagery.	Use model to relate yield to input variables based on length scale. Develop proof of concept of zone-based approach.	Integrate water related variables. Relate yield to input based on zones.	Test water related conclusions against other models. Account for salinity and water aggregation. Identify opportunities for comparison.	Complete development of models for window-based analysis. Complete models for zone-based analysis. Compare with dynamic modeling.
Objective 1.5: Predict agricultural autonomous adaptation in response to changing climate and crop productivity. **(Juntunen/Roberts/Zheng/Voels/Guinn/Gillam)**					
Perform econometric modeling of crop acreage relation to climate and market variables with data from the USDA (NASS CDL, NASS Quick Stats, Common Land Unit Boundaries parcel data), USGS (Geological and soil-type data), and Bloomberg database.	Collect public GIS, climate, economic, USDA, and USGS data. Conduct preliminary analysis of changes in extent of various crops, crop prices, input costs.	Compile GIS data: determine crop planted on each parcel annually, 19972013. Identify parcel crop rotation changes. Econometrically model historical crop changes, crop spot prices and major crop acreages at state and county levels, commodity futures prices and input prices	Develop multinomial logit/probit or other discrete outcome model to predict crop (rotation) selection on each parcel given parcel specific attributes: soil type, ecoregion, historical climate variables, etc.		
Develop economic land use model of individual landowner behavior in response to climate and market changes.	Compile spatial data. Begin developing individual land use framework using crop yields data under various market and policy situations.	Empirically identify the drivers of land use with various spatial datasets (NLCD, CDL, and CRP). Continue land use framework development.	Use the individual economic land use model developed earlier to predict land use change and agricultural profitability. Start integration with IHM, SWAT, and InVEST.	Complete integration with other models.	

Identify the psychological, social, and historical factors that contribute to decision making by ND farmers and ranchers.	Conduct 2 focus groups to develop decision making assessment item pool. Collect and analyze feedback and data gathered from focus groups and interviews.	Validate decision making assessment instrument. Collect, analyze and synthesize data.	Administer decision making assessment to ND farmers and ranchers through County Extension, and other farm organizations. Collect and analyze data for integration with other models.	Collect/analyze data for integration with other models.	Continue to collect/ analyze data for integration with models.
Objective 1.6: Explore feedback to environment of land use changes. **(Bowman/Kennedy/J. Zhang/ X. Zhang/ Zheng/Brevik/Steffan/Barnhart/DeLorme/Williams)**					
Measure CCN activation of aerosol sources important to ND.	Perform diesel PM experiments. Update chamber model.	Perform crop secondary PM experiments.	Perform oilfield PM experiments.	Perform PM mixture experiments.	
Identify possible feedback of agricultural land use change on aerosols and cloud formation in the NGP with WRF-Chem.	Identify crop emissions. Define base model configuration and scenarios.	Run base case simulations Develop new CCN parameterizations.	Run land use change scenarios. Define cloud aerosol interaction scenarios and numerical approaches.	Test sensitivity of aerosol and cloud predictions in land use change scenarios to CCN parameterizations.	Test sensitivity of aerosol and cloud predictions in land use change scenarios to cloud schemes.
Quantify impact of land use change on ecosystem services.			Begin scenario development for coupled economic land use – ecological assessment models.	Complete scenario development. Couple model with InVEST.	Couple model with SWAT. Perform coupled model simulations on scenario.
Evaluate impact of land use change on quality of water resources.		Acquire LISSTVSF meter.	Conduct field measurements. Develop method to infer water quality parameters from scattering measurements.	Conduct field measurements. Develop inversion model.	Conduct field measurements. Validate inversion results in terms of water quality parameters.

Goal 2: Build CRCS into a high functioning, interdisciplinary, sustainable regional climate and education center that includes the acquisition of state-of-the-art analytical equipment and utilization of cyberinfrastructure (CI).					
Benchmarks/ Activities	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**
Objective 2.1: Develop and foster interactions between team (UND and NDSU) members including faculty from TCs and PUIs by continually seeking to build capacity for interdisciplinary research state-wide and initiate collaboration with partner institutions (TCs and PUIs) and sustain research collaborations with TC/PUIs. **(J. Zhang/Bowman)**					
Build the CRCS team by holding meetings that include postdocs and graduate students.	Identify CRCS team members; hold monthly meetings with 90% attendance. Prepare one-page summary of CRCS research and distribute to TCs and PUIs.	Convene monthly meetings of CRCS team with 90% attendance. Convene two CRCS videoconferences.	Convene monthly meetings of CRCS team with 90% attendance. Convene two CRCS videoconferences with all partners to discuss science.	Ongoing.	Ongoing.
Continually seek to identify, initiate, integrate and foster research collaborations with faculty from partner institutions (TCs and PUIs).	Identify and initiate research collaborations with TC faculty.	Seek to identify and initiate new research collaborations with TC faculty. Integrate and foster existing research relationships with TC faculty. Identify and initiate research collaborations with PUI faculty.	Seek to identify and initiate new research collaborations with TC and PUI faculty. Integrate and foster existing research relationships with TC and PUI faculty.	Ongoing.	Ongoing.
Objective 2.2: Develop effective access to file storage through implementation of the Globus Online GridFTP data transfer tool at the NDSU site to transfer files between NDSU and UND. File transfer between the HPC sites at NDSU and UND will also be handled by Secure Copy Protocol (SCP). **(Bergstrom/ Ossowski)**					
Globus online data transfer tool.	Determine data transfer needs of CRCS researchers.	Develop efficient implementation of Globus Online Grid FTP.	Ongoing.	Ongoing.	Ongoing.

Objective 2.3: Design and build local Relational Database Management System (RDBMS) minicloud at NDSU in support of collaborative activities within the UND CRCS research cluster. **(Denton/Bergstrom/Ossowski)**					
Develop RDBMS.	Determine available funding for the RDBMS minicloud, and the appropriate location for where it will be hosted.	Architect, build, and maintain RDBMS minicloud.	Ongoing.	Ongoing.	Ongoing.
Objective 2.4: Procure a limited amount of HPC equipment needed for modeling and simulation activities. **(Bergstrom/Ossowski)**					
Procure HPC equipment.	Determine need for additional HPC equipment. Determine available funding for HPC equipment. Make purchase decision.	Procure equipment as needed.	Ongoing.	Ongoing.	Take stock of equipment condition and refresh previously purchased equipment if needed and budgets allow.

CRCS Output Metrics

Metrics *(Where baseline data is available, it is represented as an initial measure of this metric; where it is not, the Year 1 projection is used and denoted with an *)*	**Year 1**	**Year 2 (through January 31, 2016)**	**Five-Year Cumulative Targets**
Number of statistically downscaled Global Climate Models (GCM) for the Northern Great Plains	0	22	20
Number of dynamically downscaled Global Climate Models (GCM) for the Northern Great Plains	0	2	2
Number of new algorithms or models for understanding parts of regional climate variation	1	3	7
Number of integrations of Northern Great Plains data with widely used data sets	0	1	3
Number of farmer focus groups	0	2	2
Number of farmers surveyed	N/A	20	720
Globus Online Implementation	Determine need	Integrated	Integrated
RDBMS minicloud	Match needs to funding	Pending	Developed
HPC Equipment for CRCS activity	Determine need	Integrated	Integrated
Total number of peer-review publications related to CRCS topics	17	28	93
Number of collaborative peer-review publications (more than one senior author)	5	24	60
Number of peer-reviewed publications with TC and/or PUI co-authors	0	7	5
Number of peer-review publications acknowledging support from this grant	4	4	45
Total number of conference presentations relate to CRCS topics	19	50	90
Number of conference presentations acknowledging support from this grant	4	11	45
Total number of submitted research proposals related to CRCS topics	8	22	71
Number of submitted collaborative proposals	4	18	31
Number of submitted research proposals (collaborative research between UND and NDSU)	0	0	9 (M1)
Number of collaborative proposals with TC and/or PUI co-investigators	0	0	6 (M2)
Total external research funding (million $) – 5-year total is cumulative	$.04M	$2.1M	$4.0M*
Number of collaborative research grants submitted between UND and NDSU)	0	0	9 (M3)
Number of postdoctoral Students trained	1	5	10
Number of graduate students trained	18	22	70
Number of undergraduate students trained	5	10	36

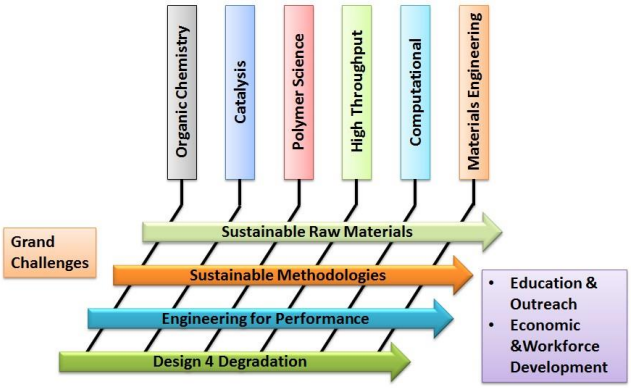
Funding for TC faculty to participate in the research centers *(ND has 5 TCs – efforts are currently underway, via campus visits to learn which TC faculty members wish to work with the CRCS or CSMS as cluster members; funds represent total funding to TCs)*	$$84,991 Direct	$87,542 Direct	$530,915 Total
Seed grant awards for PUI faculty to participate in the research center *(ND has 4 PUIs– efforts are currently underway with the ND University System to identify PUI faculty members you wish to work with the CRCS or CSMS as cluster members; funds represent total funding to PUIs)*	N/A	$124,040 Direct	$531,000 Total

* CRCS's long-term sustainability target is $1 million per year in new funding

CRCS Mitigation Plans, approved by NSF RSV panel: M1, M2, M3: CRCS will focus on moving the research collaborations among UND/NDSU/TC/PUI members initiated during Y1 and Y2 to developing collaborative proposals. CRCS/CSMS Leads/co-Leads will hold breakout session(s) during the ND EPSCoR Annual State Conference in April 2016 and make this a topic of emphasis during monthly teleconferences.

3.6 Focus Area 2-Center for Sustainable Materials Science (CSMS)

Strategic Priority: North Dakota seeks to advance new discoveries of new bio-based, sustainable materials that give more consideration to the environment and contribute to its economy through their sourcing (low cost, renewable), durable lifetimes (long, high durability), and recyclability (efficient, high value).



Goals:

1. Develop and launch a transformative approach to the development of sustainable materials derived from agricultural materials as a means to replace petrochemical polymeric materials in day-to-day use.

2. Build CSMS into a high functioning interdisciplinary, sustainable research team that includes new faculty hires, acquisition of state of the art analytical equipment and utilization of cyberinfrastructure (CI) for the purpose of efficiently processing data, quickly analyzing results, and securely transmitting data between groups.

Objectives to Achieve Goals: To achieve Goal 1, the CSMS team has identified 11 objectives with benchmark activities that are aimed to:

- Engage researchers having complementary areas of expertise via synergistic collaborations in order to fully realize the overall goal of designing new polymers and composites from renewable raw materials that have the required performance properties to replace petrochemical materials and in some cases also be capable of being reverted back to starting materials after their useful lifetime is over. Goal 1 begins with chemicals obtained from biomass such as sugars, cellulose, lignin, or seed oils, these chemicals are then transformed into the building blocks for polymers (monomers, oligomers, etc.) through chemical reactions *(objectives 1.1 and 1.2)*.

- Synthesize polymers - both thermoplastics *(objectives 1.3 and 1.4)* and thermosets *(objective 1.5)* - from these building blocks. The polymers will be thoroughly characterized and benchmarked against petrochemical counterparts. Composites will then be prepared using the bio-based polymers as matrix resins using bio-based fibers and novel bio-based nanofibers as filler materials *(objectives 1.6, 1.7 and 1.8)*. A main component in sustainability is in understanding the fate of the materials at the end of their useful lifetime. Thus, a key aspect of our program is to devise processes that enable materials to be reverted back to starting materials at the end of their useful life using a specific triggering mechanism. Specific triggerable components that can function as monomers will be synthesized *(objective 1.9)* and incorporated into the bio-based polymers *(objective 1.10)*. The impact of these monomers on the overall properties of the polymers will be assessed, as will the mechanism of the degradation of the polymer when excited by the trigger.

- Develop novel triggers derived from biomass, so that a substantial portion of the polymer is derived from bio-based raw materials. The ability to take the degradation products and re-synthesize new

polymers will be demonstrated. Finally, bio-based polymers containing the triggerable component will be used in the preparation of composites and the ability to degrade the composite and recover both monomers and fiber fillers will be demonstrated *(objective 1.11)*.

Goal 2 will be achieved by completing five objectives with benchmark activities that are aimed to:

- Create a sustainable and collaborative infrastructure (human, computational, and instrumental) for sustainable materials science. This project integrates previously isolated research activities in ND and enables us, for the first time, to tackle this interdisciplinary research topic that is significant to ND. *Objectives 2.1* and *2.2* aim to facilitate a collaborative and integrated effort among group members from across disciplines at UND, NDSU, PUIs and TCs, which is to be greatly strengthened by the hiring of four additional faculty members (*objective 2.3*). Researchers from the two research universities, UND and NDSU, provide core expertise. Team members from the PUIs and TCs will add more diverse geographical and cultural perspectives, while strengthening research efforts at these institutions and collaborations between institutions using newly acquired analytical equipment (o*bjective 2.4*).

- Develop robust cyberinfrastructure necessary to support information exchange and collaborative research activities within the Center. The CI team will develop/upgrade cyberinfrastructure, including possible enhancement to High Performance Computing (HPC) file systems *(objective 2.6)*, implementation of the Globus Online GridFTP data transfer tool (*objective 2.5*), and possible enhancement to the HPC modeling and simulation capabilities (*objective 2.6*).

Team Leads: CSMS Director, **Dean Webster** (Professor and Chair, Coatings and Polymeric Materials, NDSU) leads research in polymer synthesis, coatings, and polymer structure-property relationships and the use of high throughput methods. The CSMS co-Lead, **Mukund Sibi** (Distinguished Professor, Chemistry and Biochemistry, NDSU), has expertise in catalysis and organic synthesis.

Team Participants and Partners:

- **Mikhail Bobylev** (Professor, Science – Chemistry, MiSU) synthesizes novel polymers from biomass using a method he recently patented.
- **Qianli "Rick" Chu** (Assistant Professor, Chemistry, UND) focuses on the synthesis of nanofibers from bio-based monomers.
- **Guodong Du** (Associate Professor, Chemistry, UND) targets catalytic and stereoselective synthesis of biodegradable polymers that are based on renewable raw materials.
- **Khwaja Hossain** (Associate Professor, Science and Mathematics, MaSU) studies bio-based composite synthesis using wheat bran.
- **Alena Kubatova** (Professor and Director of Recruitment, Chemistry, UND) studies analytical chemistry, valorization of lignins, chromatographic and mass spectral analysis.
- **Zoltan Madjik** (Associate Professor, Communication, NDSU) communicates the science of the center.
- **Mafany Ndiva Mongoh** (Instructor, Ag/Science, SBC) studies sustainable biodegradation of polymers - impact of microorganisms in the environment
- **Alexander Parent** (Assistant Professor, Chemistry, NDSU) studies monomer synthesis.
- **Mohiuddin Quadir** (Assistant Professor, Coatings & Polymeric Materials, NDSU) studies bio-based polymer synthesis.
- **Jayaraman Sivaguru** (Professor, Chemistry/Biochemistry, NDSU) studies photochemistry, organo- and supramolecular photocatalysis, molecular recognition and photodegradation.

- **Chad Ulven** (Associate Professor, Mechanical Engineering, NDSU) studies the field of composites, with an emphasis on using naturally-occurring fibers as fillers.
- **Andriy Voronov** (Associate Professor Coatings and Polymeric Materials, NDSU) brings polymer synthesis expertise to the team.

The research center members will place an emphasis on leveraging existing North Dakota talent with proven track records of creativity and productivity. In addition, leveraging and interactions will be implemented with all other program components, the primarily undergraduate state universities, tribal colleges, businesses, local and national media, other potential research partners and governmental agencies.

Key Outcome: Increased state-wide physical, human and research assets to progress the development of a sustainable bio-based materials supply chain.

Table 3. Focus Area 2 Goals, Objectives, Benchmarks and Activities, Output Metrics and Baseline and 5-year Targets

Goal 1: Develop and launch a transformative approach to the development of sustainable materials derived from agricultural materials as a means to replace petrochemical polymeric materials in day-to-day use.					
Benchmarks/ Activities	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**
Objective 1.1: Synthesize novel monomers from biomass. **(Sibi/Parent)**					
Build a library of bio-based monomers for use in a variety of polymer systems. **(Sibi)**	Continue synthesis of HMF-derived monomers.	Synthesize new Diol and diaminemonomers.	Synthesize chain extended analogs of FDCA.	Synthesize new terephthalic acid analogs.	Synthesize HMF-dimer, analog mod./ new monomers.
Develop novel oxidation technology using O_2 for monomer synthesis. **(Parent)**	N/A – new hire in Y2.	Test feasibility of photocatalytic oxidation using oxygen gas for the synthesis of sustainable polymer monomers.	Mechanistic study on dioxygen activation.	Model studies on oxidation of chemical feedstocks. Model studies on oxidation of renewable chemical feedstocks.	Develop new routes for the synthesis of succinic acid from biomass feedstock
Develop new analytical methods for products from valorization of lignins **(Kubatova)**			Analyze products from breakdown of lignins.	Quantify monomers and oligomers from breakdown of different types of lignin sources and different methods of valorization.	Identify optimal monomers from lignins for use in synthetic work.
Objective 1.2: Design new highly functional thermosetting polymers. **(see activity assignments below)**					
Build a library of novel biobased polymers having different useful functional groups. **(Webster)**	Ongoing activities to synthesize and characterize new methacrylate functionalized sucrose soyate resins.	Synthesize and characterize carbonated sucrose soyate resins.	Identify new core molecules and synthesize vegetable oil ester resins.	Identify new methods of increasing the functionality of bio-based resins.	Continue work with most promising approach for achieving exceptional performance properties.

Synthesize new vinyl ether monomers from biomass derived chemicals. **(Voronov)**	Use known synthetic procedures to synthesize and characterize novel plant oil-based vinyl ethers.	Evaluate the utility of plant oil-based poly (vinyl ether)s for potential end-use applications.	Synthesize and characterize novel poly (vinyl ether)s based on derivatives of hydroxymethylfurfural.	Synthesize and characterize polymers derived from acrylate and methacrylate monomers based on hydroxymethyl-furfural and/or its derivatives.	Optimize polymers to obtain best performance properties (stiffness, strength, etc.).
Objective 1.3: Engineer high performance polymers and composites from bio-based raw materials. Benchmark against current appropriate petrochemical counterparts. **(Voronov/Quadir/Bobylev)**					
Synthesize new polyamides derived from novel bio-based monomers and synthesize new polyesters made from bio-based monomers. **(Voronov)**	Use FDCA and other novel biobased monomers (Sibi) to synthesize polyamides. Characterize physical and mechanical properties.	Continue effort with new monomers as they become available.	Continue effort with new monomers; use FDCA and other novel based monomers to synthesize polyesters.	Characterize physical and mechanical properties of the polymers.	Continue effort with new monomers as they become available out of #1.1.
Develop novel biopolymers from biomass derived building blocks. **(Quadir)**	N/A – new hire in Y2.	Synthesize biodegradable, programmable and self-assembling polymers from biobased monomers such as FDCA (Sibi) and ESS. (Epoxydized sucrose soyate).	Characterize physical and biophysical properties of synthesized polymers. Evaluation of toxicity and immunogenic properties of these biobased functional polymers in cells and animal models.	Continue effort with new monomers as they become available from the consortium (Sibi). Identifying facile and scalable synthetic routes and assembly methods to generate value-added materials and products from these biobased polymers.	Comparison of efficiency of the synthesized materials with existing standard, and adjusting structure-property relationship of the former to excel the current state of the art.
Develop novel polymers from biomass **(Bobylev)**	N/A – PUI seed award in Y2.	Carry out proof of principle experiments of polymer formation using amines and terephthalaldehyde.	Carry out proof of principle experiments of polymer synthesis using amides and terephthalaldehyde.	Synthesize polymers from furandialdehyde (Sibi) and amines and amides.	Extend the polymer synthesis to other biomass derived dialdehydes (Sibi).

Objective 1.4: Synthesize bio-based polymers using "green" catalyst systems. **(Du)**					
Synthesize and use novel inorganic catalysts for polymer synthesis.	Synthesize binucleating ligands and catalysts for polycarbonate formation.	Produce polyesters incorporating biobased epoxides and cyclic anhydrides.	Synthesize block copolymers and evaluate properties.	Develop and synthesize new ligands and catalysts for stereoselective polylactide synthesis.	Synthesize new degradable polymers from bio-based building blocks such as diacids and diols.
Objective 1.5: Prepare bio-based thermosets and characterize for physical properties. Benchmark against current appropriate petrochemical counterparts. **(Webster)**					
Synthesize novel high performance thermosets useful for coatings and composites.	Combine available biobased epoxy resin with biobased crosslinkers (Sibi) and prepare and characterize thermosets. Benchmark against petrochemical thermosets.	Crosslink new bio-based resins with bio-based and petrochemical crosslinkers and characterize thermosets for physical and mechanical properties.	Crosslink carbonated sucrose ester resin with novel bio-based diamines and characterize properties.	Use novel HMF based monomers (Sibi) as crosslinkers for bio-based resins. Characterize for physical and mechanical properties.	Characterize corrosion of new thermosets performance in coatings as well as weathering durability using QUV or xenon arc for moisture/heat FTIR, etc. methods for degradation mechanism.
Objective 1.6: Use bio-based polymers in the preparation of composites. Benchmark against current appropriate petrochemical counterparts. **(Webster/Ulven)**					
Study and optimize curing kinetics of newly developed resins prior to composite manufacturing.	Provide biobased resins from Webster to Ulven group for formulation of resin systems for composites. Prepare initial composites. Determine physical and mechanical properties.	Study and optimize cure kinetics of biobased resin system for use in composites.	Provide new bio-based polymer systems from Webster to Ulven group for use in preparation of composites. Characterize new composites for physical and mechanical properties.	Continue to refine and optimize resin compositions and cure kinetics for use in composite systems.	Continue to refine and optimize resin compositions and cure kinetics for use in composite systems.
Objective 1.7: Study performance properties of composites made using bio-based fillers and fibers. Benchmark against current appropriate petrochemical counterparts. **(Ulven/Hossain)**					
Develop new totally bio-based composite systems. **(Ulven)**	Evaluate both physical and mechanical properties of composites from natural fibers.	Tailor fiber sizing or treatment approaches to improve interfacial load transfer between natural fibers and bio-based polymers.	Evaluate composites through freeze/thaw, UV, and humidity exposure.	Model long term performance of optimized biocomposites using known micromechanical models for synthetic composites.	

Study performance properties of composites made using bio-based fillers and fibers. **(Hossain)**	N/A – PUI seed award in Y2.	Characterize different wheat bran varieties and initiate treatments to isolate constituents.	Optimize wheat bran treatments for use as beneficial fillers in thermoplastics.	Develop different thermoplastic biocomposites using treated wheat bran.	Optimize treated wheat bran filled thermoplastics biocomposites for best performance.
Objective 1.8: Synthesize novel bio-based nanoreinforcements. **(Chu)**					
Develop new types of biobased reinforcements for bio-based polymers.	Synthesize and characterize biobased polymeric ladders.	Synthesize and characterize biobased 2D polymers.	Evaluate the biobased ladder and 2D polymers in coatings as crosslinking agents (with Webster group).	Synthesize and characterize biobased 3D polymers.	Evaluate the 3D polymers in coatings as crosslinking agents (with Webster group).
Objective 1.9: Design materials with programmed degradation capability so that raw materials and fillers can be recycled. **(Sivaguru/Sibi/Voronov/Mongoh)**					
Develop new biomass derived phototriggers and photoinitiators that can be incorporated into polymers; synthesize building blocks that can be used to trigger polymer degradation.	Continue efforts in the synthesis of phototriggers; conduct degradation and mechanistic studies of phototriggers.	Explore routes to the synthesis of novel phototriggers from biomass and evaluate approaches.	Synthesize and evaluate photo-initiators for their ability to photoinitiate radical polymerization derived from biomass.	Broaden approaches to alternative phototriggers and photoinitiators from biomass and evaluate.	Elucidate the mechanism of photodegradation of photo-triggers using photophysical characterization methods.
Develop methods for sustainable biodegradation of polymers. **(Mongoh)**	N/A – TC researcher identified at end of Y1.	Identify microbes for biodegradation of polymers	Carry out preliminary experiments for biodegradation of polymers synthesized by CSMS researchers. (Sibi, Sivaguru, Webster, Voronov)	Optimize microbial degradation of thermosets. (Webster)	Expand and optimize microbial degradation technique to other types of polymers. Synthesized by CSMS researchers (Sibi, Sivaguru, Webster, Voronov)
Develop methods for sustainable degradation of lignin.	N/A – TC researcher identified at end of Y1.	Carry out preliminary experiments on the identification of bacterial/fungal enzyme based degradation of lignin	Identify the optimal bio-source for the degradation of lignin.	Characterize lignin degradation products using analytical techniques (GC, NMR, RP-HPLC, IR).	Degrade polymers prepared from lignin-derived monomers.

Objective 1.10: Incorporate triggerable building blocks into polymers and thermosets in order to yield polymers with programmed degradation capability. **(Webster/Sivaguru/Sibi)**					
Synthesize polymers that can be degraded using light.		Incorporate new phototriggers into additional polymer types. Characterize the photodegradation of polymers containing the phototriggers.	Incorporate novel bio-mass derived phototriggers into polymers and study photodegradation.	Incorporate biomass-derived phototriggers into thermosetting resin systems and study photodegradation.	Demonstrate re-use of degradation products in synthesis of new polymers.
Objective 1.11: Incorporate photodegradable polymers into composite systems. **(Ulven/Webster/Sibi/Sivaguru)**					
Develop composites that can be degraded using light in order to recover reinforcing fibers.				Use polymer containing phototriggers in the preparation of composites using natural fibers.	Study the degradation of the composites and demonstrate the recovery of reinforcing natural fibers.
Goal 2: Build CSMS into a high functioning interdisciplinary, sustainable research team that includes new faculty hires, acquisition of state of the art analytical equipment and utilization of cyberinfrastructure (CI) for the purpose of efficiently processing data, quickly analyzing results, and securely transmitting data between groups.					
Benchmarks/ Activities	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**
Objective 2.1: Develop and build interactions between team (UND and NDSU) members including faculty from TCs and PUIs by continually seeking to build capacity for interdisciplinary research state-wide and initiate collaboration with partner institutions (TCs and PUIs) and sustain research collaborations with TC/PUIs. **(Webster/Sibi)**					
Build the CSMS team by holding meetings that include postdocs and graduate students.	Identify CSMS team members; hold monthly meetings with 90% attendance; prepare one-page summary of CSMS research and distribute to TCs and PUIs.	Convene monthly meetings of CSMS team with 90% attendance. Convene two CSMS video-conferences.	Convene monthly meetings of CSMS team with 90% attendance. Convene two CSMS video-conferences with all partners to discuss science.	Ongoing.	Ongoing.
Continually seek to identify, initiate, integrate and foster research collaborations with faculty from partner institutions (TCs and PUIs).	Identify and initiate research collaborations with TC faculty.	-Seek to identify and initiate new research collaborations with TC faculty. -Integrate and foster existing research relationships with TC faculty. -Identify and initiate research collaborations with PUI faculty.	-Seek to identify and initiate new research collaborations with TC and PUI faculty. -Integrate and foster existing research relationships with TC and PUI faculty.	Ongoing.	Ongoing.

Objective 2.2: Develop collaborative, interdisciplinary projects among CSMS team members. **(Webster/Sibi)**					
Collaborative projects with interdisciplinary teams lead to joint proposal submissions.	Develop time-based work plans for each collaborative project.	Execute work plan and assess progress during CSMS team meetings.	Continue proposal writing and review; plan for center-type proposal.	Submit at least one center-type proposal; review results, amend plan if needed.	Develop plan for continued collaborative, inter-disciplinary projects and proposal writing.
Objective 2.3: Strengthen CSMS research infrastructure with four new hires (hiring plan is in the appendix section). **(Sibi/Webster)**					
Hire four new faculty members and support their integration into the CSMS team.	Prepare descriptions of positions. Initiate searches, interview, select faculty, and hire two: One synthetic organic chemist and one polymer scientist.	Synthetic organic chemist and polymer scientist start FA15, attend CSMS orientation. Confirm mentors, both establish goals and performance measure. Prepare for hiring computational polymer scientist.	Synthetic organic chemist and polymer scientist submits CAREER proposal. New computational polymer scientist and scientist with expertise in life cycle assessment start in FA16.	Computational polymer scientist and scientist with expertise in life cycle assessment submit CAREER proposals. All new hires attain 90% of their performance measures Plans reviewed and revised if needed.	Resubmission of CAREER proposals that were not awarded. Review of tenure and promotion status. Plan constructed for support through tenure and promotion attainment. Review of performance.
Objective 2.4: Acquire needed analytical equipment. **(Webster/Sibi)**					
Identify and prioritize CSMS team needs for supporting new analytical capabilities; acquire equipment, make operational and utilize.	Determine purchasing budget and meet with CSMS team members to develop time-based plan.	Initiate purchases and complete those that are started. Train users (faculty, students and postdocs).	Develop protocols for sharing analytical equipment.	Document usage, maintain equipment and plan for additional equipment.	Include additional equipment in CSMS research proposals; plan for the future.
Objective 2.5: Develop effective access to file storage through implementation of the Globus Online GridFTP data transfer tool at the NDSU site to transfer files between NDSU and UND. File transfer between the HPC sites at NDSU and UND will also be handled by Secure Copy Protocol (SCP). **(Bergstrom/Ossowski)**					
Globus Online data transfer tool.	Determine data transfer needs of CSMS researchers.	Develop efficient implementation of Globus Online Grid FTP.	Ongoing.	Ongoing.	Ongoing.

Objective 2.6: Procure a limited amount of HPC equipment needed for modeling and simulation activities. **(Bergstrom/Ossowski)**					
Procure HPC equipment.	Determine need for additional HPC equipment. Determine available funding for HPC equipment. Make purchase decision.	Procure as needed.	Ongoing.	Ongoing.	Take stock of equipment condition and refresh previously purchased equipment if needed and budgets allow.

CSMS Output Metrics

Metric *(Where baseline data is available, it is represented as an initial measure of this metric; where it is not, the Year 1 projection is used and denoted with an *)*	**Year 1**	**Year 2 (through January 31, 2016)**	**Five-Year Cumulative Targets**
Number of new synthesized new monomers	23	22	40
Number of new thermoset polymers	32	56	20
Number of new synthesized vinyl ether monomers	7	5	18
Number of synthesized new polyamides	4	0	12
Number of synthesize new polyesters	15	4	12
Number of synthesize inorganic catalysts	5	3	18
Number of high performance thermosets evaluated	19	87	12
Number of resin formulations developed	6	13	12
Number of bio-based composites	6	3	10
Number of synthesized reinforcement polymers	4	3	15
Number of synthesized phototriggers-photo initiators	4	2	15
Number of new polymers for photodegradation studies	2	1	12
Number of composites for photodegradation studies	N/A	N/A	6
Globus Online Implementation	N/A	Determining need	Integrated
HPC Equipment for CSMS activity	N/A	Determining need	Integrated
Number of submitted collaborative proposals	5	5	15
Number of new hires	2	0	4
Number of CAREER proposals submitted	0	0	2-4
Number of new analytical instruments acquired	0	4	2
Number of postdoctoral associates trained	5	7	7
Number of graduate students trained (some may be counted in multiple years)	15	19	25
Number of undergraduate students trained	14	14	40
Number of peer-reviewed publications	5	6	48
One collaborative peer-reviewed publication by each CSMS TC and/or PUI faculty	0	0	6-8 (M1)
Number of conference presentations by faculty (oral and poster)	25	9	40
Number of conference presentations by graduate students and postdocs (oral and poster)	23	5	63
Number of conference presentations by undergraduate students (oral and poster)	4	1	40 (M3)
Percentage of all publications in high-impact journals	75%	75%	25%
Number of cumulative citations	5	25	200
Number of invention disclosures submitted	5	5	10
Number of projects funded with private sector partners (includes SBIR/STTR)	1	2	12 (M2)
Funding for TC faculty to participate in the research centers *(ND has 5 TCs – efforts are currently underway, via campus visits to learn which TC faculty members wish to work with the CRCS or CSMS as cluster members; funds represent total funding to TCs)*	$84,991 Direct	$87,542 Direct	$530,915 Total

Seed grant awards for PUI faculty to participate in the research center *(ND has 4 PUIs– efforts are currently underway with the ND University System to identify PUI faculty members you wish to work with the CRCS or CSMS as cluster members; funds represent total funding to PUIs)*	N/A	$124,040 Direct	$531,000 Total

CSMS Mitigation Plans, approved by NSF RSV panel:

- M1: This metric is behind schedule because CSMS spent much of Y1 engaging TC and PUI researchers and identifying the research topics and interactions that were a good fit with the CSMS thrust. Research activities related to many of these collaborations just got underway this past fall, so the work has not reached a point where publications are feasible. In our mitigation plan, the CSMS researchers who are collaborating with the TC and PUI researchers are intent on ensuring that this important metric is met. CSMS' collaborative research plans are directed toward activities that will lead to results that can be published in peer-reviewed scientific journals. We are ensuring that steady progress is being made through regular interactions between the collaborators beyond our monthly IVN meetings via phone calls and emails and plans are being made for periodic personal visits to discuss research progress and goals. The opportunities for adding student researchers via REU and other programs can further accelerate the research progress ensuring that this goal is met.
- M2: CSMS researchers will work with the Partnerships, Collaborations and Communication team to utilize the resources they are developing in their Action Plan related to their Goal 1.
- M3: Although behind, CSMS is confident that metric goal will be obtained as undergraduate research progresses through opportunities such as the ND EPSCoR Annual State Conference.

3.7 Focus Area 3-Diversity

Strategic Priority: Build on the success of our Nurturing American Tribal Undergraduate Research and Education (NATURE) programs by continuing to nurture American Indian students throughout their undergraduate and graduate work; particularly in STEM areas. Continue and expand supportive connections between research themes and underrepresented communities, including female participation in STEM.

Goals:

1. Build on the success of our K-12 NATURE programs by continuing to nurture American Indian students throughout their undergraduate and graduate work by advancing the collaborative relationship with the 5 Tribal Colleges (TCs) located in North Dakota and by building on our collaboration with PUIs to strengthen the partnership, thereby resulting in increased research participation from both of those groups.

2. Develop new initiatives that result in American Indian student retention and completion in STEM areas.

3. Partner with existing campus groups to expand efforts to increase participation of women in STEM; with specific focus on women in science and engineering (ND-WISE) initiatives.

Objectives to Achieve Goals: Advancing the collaborative relationship between research universities and the North Dakota Tribal Colleges requires a tribal colleges liaison focused on improving interactions between the two (*objective 1.1*). Additionally, for the clusters to achieve increased research participation from TCs and PUIs, information gathering and dissemination are critical (*objective 1.2*) and should be facilitated by the tribal colleges liaison (for TCs) and project co-directors (for PUIs). The interactions and integrations between research clusters and NATURE Sunday Camp and Summer Camp serve to stimulate interests in the themes of the clusters leading to increased research participation from American Indian students. Due to limited resources (*objective 1.3, 1.4*), American Indian students need help to be academically successful, particularly at the doctoral level. Support systems such as American Indian advisers, tutoring programs, and fellowships/assistantships are crucial for enhancing American Indian student retention and completion in STEM areas from undergraduate to Ph.D. levels (*objectives 2.1, 2.2*).

Similar to American Indian students, support systems including seed/position funding and mentoring programs increase the number of women faculty in STEM areas and women faculty role models through NATURE Sunday Academy and Summer Camp (*objective 3.2*). As a result, this is expected to lead to higher retention of women faculty and students in STEM areas, and more successful promotion and tenure cases for women faculty (*objective 3.1*).

Team Leads: Diversity team lead, **Eakalak Khan** (Professor Civil Engineering, NDSU) serves as the ND EPSCoR NATURE Coordinator and is the Director of the NDSU Environmental & Conservation Science Program with research interests in water and wastewater. The Diversity co-Lead, **Chad Ulven** (Associate Professor, Mechanical Engineering, NDSU) serves as the NATURE Sunday Academy Coordinator and is a member of the CSMS group.

Team Participants:

- **Scott Hanson (**ND EPSCoR Tribal Colleges Liaison – since May 2015) provides liaison expertise between NDSU, UND and the TCs for all facets of the program.

- **Mark Hoffmann** (ND EPSCoR Associate Project Director) serves as a team/EPSCoR leadership facilitator for the team, specifically its UND members.
- **Jean Ostrom-Blonigen** (ND EPSCoR Project Administrator) serves as a team/EPSCoR leadership facilitator for the team, specifically its NDSU members and filled the role of the Tribal Colleges Liaison Manager until Scott Hanson was hired in May 2015.
- **Robert Pieri** (Professor, ME, NDSU) coordinates NATURE University and Tribal College Summer Camps
- **Kathleen Wahlberg** (ND EPSCoR Project Assistant, NDSU) provides administrative supports including but not limited to hiring/terminating employees, payrolls, travel vouchers, purchasing and reimbursements, billeting, catering requests, and motor pool reservations.
- **All members** of both research clusters will be expected to engage in the activities outlined in the table below. The specific activity will determine the linked faculty member.
- **Cankdeska Cikana Community College** – administrators, faculty and students.
- **Nueta Hidatsa Sahnish College**– administrators, faculty and students.
- **Sitting Bull College** – administrators, faculty and students.
- **Turtle Mountain Community College** – administrators, faculty and students.
- **United Tribes Technical College** – administrators, faculty and students.

Key outcomes: 1) Increased climate and agro-economy scientific capacity within the tribal communities; 2) Increased number of American Indians completing STEM degrees; and 3) Increased number of women STEM faculty at NDSU and UND.

Status of Tribal Colleges Liaison Manager position: As of 1/15/15, the Tribal Colleges Liaison Manager position description, developed in conjunction with the TC presidents, was under review by NDSU's Recruiting Office. Once approved, the position opening will be advertised for 10 days and the screening process will begin. Search committee members include:

- Chair: Jean Ostrom-Blonigen, ND EPSCoR Program Administrator, NDSU
- Mark Hoffmann, ND EPSCoR Associate Program Director, UND
- Jaclynn Wallette, Assistant VP for Equity, Diversity, and Global Outreach, NDSU
- Leigh Jeanotte, Director, American Indian Student Services, UND
- Jennifer Janecek-Hartman, Director, ND Association of Tribal Colleges

[3/17/16 Update: Scott Hanson was hired as ND EPSCoR Tribal Colleges Liaison Manager in May 2015. Prior to joining ND EPSCoR, Dr. Hanson spent 19 years at TMCC teaching life sciences, mentoring student research and managing grants. Dr. Hanson also chairs the EMPOWERED-ND Corps.]

Table 4. Focus Area 3 Goals, Objectives, Benchmarks and Activities, Output Metrics and Baseline and 5-Year Targets

Goal 1: Build on the success of our K-12 NATURE programs by continuing to nurture American Indian students throughout their undergraduate and graduate work by advancing the collaborative relationship with the 5 Tribal Colleges (TCs) located in North Dakota and by building on our collaboration with PUIs to strengthen the partnership, thereby resulting in increased research participation from both of those groups of students.					
Benchmarks/ Activities	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**
Objective 1.1: Hire a tribal colleges liaison to facilitate interactions between the research universities (NDSU and UND) and the TCs. **(Hanson/Ostrom-Blonigen)**					
Tribal Colleges Liaison Position is filled.	Develop plan by engaging stakeholders and hire liaison.	Retain liaison with satisfactory reviews of performed duties.	Ongoing.	Ongoing.	Retain liaison with satisfactory reviews and institutionalize position.
Tribal Colleges Liaison: Growing the research.	Meet with research center leads and/or liaisons.	Identify 5 TC faculty interested in engaging in CRCS or CSMS complementary research	Add Cohort 1 undergraduate researchers.	Add Cohort 2 UG researchers.	Add Cohort 3 UG researchers.
Tribal Colleges Liaison: Communication.	Develop a TC EMPOWERED-ND communication.	Communicate on state stage.	Communicate on state and national stages.	Write policy paper describing communication efforts of EMPOWERED-ND.	Champion broader EPSCoR and TC interaction.
Objective 1.2: Gather and disseminate information the clusters need to integrate TC and PUI participants into their projects. **(Hanson/Ostrom-Blonigen/Hoffmann)**					
EMPOWERED-ND Corps (in person or online IVN meetings) to assess progress and review/revise implementation plans.	Appoint cluster personnel. Hold initial meeting.	Host semiannual face-to-face meetings at central ND college location (an IVN option will be available for each of these meetings).	Ongoing.	Ongoing.	Ongoing.

Continuously gather program and funding information to aid in ongoing decision making.	Inventory current program pitfalls; target and eliminate overlap. Identify and leverage existing funding. Recommend new programs to further engage and broaden participation.	Provide feedback to researchers to ensure continued participation. Update baseline inventories. Identify and leverage existing funding. Recommend new programs.	Ongoing.	Ongoing.	Ongoing.
Disseminate information.	Host semiannual meetings with ND EPSCoR Steering Committee.	Ongoing.	Ongoing.	Ongoing.	Ongoing.
Objective 1.3: Include more cluster research themes into university summer camps in order to enhance student participation in STEM. **(Khan/Pieri/J. Zhang/Webster/Hanson)**					
Perform student tracking.	Develop measurement tool for longitudinal study.	Implement by cohort and assess effectiveness.	Ongoing, with tool modifications as necessary.	Ongoing.	Ongoing.
Track research cluster involvement and demographics	Track faculty, postdocs and graduate students	Ongoing.	Ongoing.	Ongoing.	Ongoing.
Collaborate with cluster research liaisons at summer camp planning development lessons	Collect tracking data of cluster research related lessons developed, and faculty involved.	Ongoing.	Ongoing.	Ongoing.	Ongoing.
Objective 1.4: Increase the integration of the Sunday Academy programming with the research clusters. **(Khan/Ulven/ J. Zhang/Webster/Hanson)**					
Perform student tracking.	Develop measurement tool for longitudinal study.	Implement tracking by cohort and assess effectiveness.	Ongoing.	Ongoing.	Ongoing.
Increase the number of cluster faculty, post-docs, and graduate students involved.	Collect tracking data by cohort.	Ongoing.	Ongoing.	Ongoing.	Ongoing.

Increase the number of cluster research related lessons.	Collaborate at summer camp and during other opportunities that arise.	Ongoing.	Ongoing.	Ongoing.	Ongoing.
Goal 2: Develop new initiatives that result in American Indian student retention and completion in STEM areas.					
Benchmarks/ Activities	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**
Objective 2.1: Support American Indian STEM students so that they are successful. **(Hanson/ Hoffmann/Ostrom-Blonigen/Webster/Sibi/J. Zhang/Bowman)**					
Develop and embed the support system at NDSU and UND.	Hire American Indian advisors.	Initiate a support plan for students, which includes math readiness.	Evaluate and modify plan as necessary.	Ongoing. Explore institutionalization of positions.	Ongoing. Institutionalize support system.
Integrate American Indian students into STEM research.	Review existing models of retention practices in other successful programs. Meet with researchers to discuss.	Meet TC presidents each year (or two) to review role of STEM advisors on each of their campuses. In the event that American Indian advisors cannot be hired by the end of Y2, our mitigation plan will include working with the presidents of each TC to determine how to best identify students for this program and support them once they are identified.	Place Cohort #1 American Indian students in research groups.	Assess the success rates of students in research groups. Initiate Cohort #2.	Assess the success rates of students in research groups. Initiate Cohort #3.

Objective 2.2: Assist American Indian students to pursue and eventually obtain PhDs in STEM programs while maintaining contact with TCs. **(Hanson/Hoffmann/Ostrom-Blonigen)**					
Support 5 students as they progress toward a STEM Ph.D. (select individual faculty once students are identified with an academic department).	Open application and identification of one student from each site by Research Cluster, EPSCoR admin, and each TC president.	Enroll 5 students. In the event that American Indian students do not come forward by the end of Y2, our mitigation plan will include working with the presidents of each TC to determine how to best identify students for this program and support them once they are identified.	Gather feedback from students. Retain students.	Ongoing.	Ongoing.
Goal 3: Increase the participation levels of women faculty.					
Benchmarks/ Activities	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**
Objective 3.1: Partner with existing campus groups to expand efforts to increase participation of women in STEM; with specific focus on women in science and engineering (ND-WISE) initiatives. **(Hoffmann/Ostrom-Blonigen/ Webster/Sibi/J. Zhang/Bowman)**					
Identify tenure-track women faculty in STEM fields at NDSU and UND	Work with existing campus mentoring programs for women faculty to communicate the availability of EPSCoR funds (state) to women faculty in tenure-track STEM programs. Award EPSCoR seed grants.	Augment existing campus mentoring programs focused on partnering experienced STEM research role models in the research clusters with non-tenured women faculty who are tenure track. Award EPSCoR seed grants.	Augment existing mentoring programs for tenure-track women faculty in STEM disciplines. Award EPSCoR seed grants.	Ongoing.	Ongoing. Evaluate efforts.

Objective 3.2: Increase the number of American Indian and women role models participating in NATURE programming. **(Khan/Pieri/Ulven/Hanson)**					
Track the number of women faculty, post-docs, and graduate students.	Gather baseline participation metrics.	Increase participation.	Ongoing.	Ongoing.	Ongoing.

Diversity Output Metrics

Metrics ***(Where baseline data is available, it is represented as an initial measure of this metric; where it is not, the Year 1 projection is used and denoted with an *)***	**Year 1**	**Year 2 (through January 31, 2016)**	**Five-Year Cumulative Targets**
Hire Tribal Colleges Liaison	Hired	Continuing	Retained
Funding for TC faculty to participate in the research centers *(ND has 5 TCs – efforts are currently underway, via campus visits to learn which TC faculty members wish to work with the CRCS or CSMS as cluster members; funds represent total funding to TCs)*	$84,991 Direct	$87,542 Direct	$530,915 Total
Seed grant awards for PUI faculty to participate in the research center *(ND has 4 PUIs– efforts are currently underway with the ND University System to identify PUI faculty members you wish to work with the CRCS or CSMS as cluster members; funds represent total funding to PUIs)*	N/A	$124,040 Direct	$531,000 Total
Number of meetings of the EMPOWERED-ND Corps	N/A	Met 5 of 7 months	At least every other month
Add UG researchers each year to the clusters identified through NATURE	N/A	3	5-15
Hire American Indian advisors with STEM backgrounds to advise American Indian students at NDSU and UND: NASSE	N/A	UND: Hire made during Summer 2016 NDSU: First meeting following holding pattern, pending reorganization of unit was held on 8/26/16	2 – ½ time (M1)
Meet annually with TC presidents to report on the impacts of the collaboration efforts between the research centers and the TCs. Report also on the numbers of American Indian students who are taking advantage of the programming	2	1	Once Annually
Place American Indian students in research group: NATURE+	9 participated in 2015 University Summer Camp INBRE pilot program	*Camp held June 6-17, 2016*	5-15
Identify American Indian students interested in obtaining a STEM Ph.D. and are willing to maintain contact with a TC faculty member or administrator: NASSE	N/A	0	5 (M1)
Assist American Indian students in obtaining their doctorate degree: NATURE+	N/A	0	5 (M1)

Identify American Indian students interested in obtaining a STEM M.S. degree and are willing to maintain contact with a TC faculty member or administrator: NASSE	N/A	1	5 (M1)
Assist American Indian students in obtaining their M.S. degree: NATURE+	N/A	0	5 (M1)
Identify American Indian students with a STEM bachelor's degree who are interested in obtaining a M.S. degree in Education and who would be willing to return to a ND tribal community and teach either at the K-12 or TC level: NATURE+	N/A	0	5 (M1)
Increase the number of newly promoted and/or tenured women faculty in STEM programs at NDSU and UND: WISE-related	N/A	12	2
Number of TC cluster faculty	6	5	2-3 per cluster
Number of cluster themes integrated with university summer camps: NATURE+	2	*Camp held June 6-17, 2016*	2-3
Number of cluster faculty/post-docs/GRA	3	5	2-3
Number of cluster themes integrated with Sunday Academy programs: NATURE+	2	3	2-3
Number of women involved in NATURE: WISE-related	33 women, 8 of whom are American Indians	18 women, 6 of whom are American Indians	10 women 10 American Indians
Award EPSCoR seed grants to women faculty: WISE-related	1	1	8+

Diversity Mitigation Plans, approved by NSF RSV panel:

M1- Under our Mitigation Plan for NASSE (Native American Success in Science and Engineering), NDSU and UND will continue in our efforts to seek to hire American Indian advisors or find ways to augment existing efforts. [UPDATE: During the summer of 2016, UND has successful in hiring Tyson Jeanotte, to serve in this capacity.] However, NASSE and our related NATURE+ have gotten off to an extremely slow start. We have come to believe that we are approaching it from the wrong end: "Research University to Tribal College" instead of "Tribal College to Research University." Thus, beginning with our NATURE+ pilot program last summer (June 2015), we added American Indian students attending a TC located in ND. This year's program (June 2016) will be extended to include American Indian students attending a ND PUI. Additionally, if we continue to be unsuccessful in hiring American Indian advisors, we would like to repurpose those funds to pay tiered stipends to American Indian students, who attend the NATURE+ summer camp, as follows:

- Junior-level+ undergraduate students in a bachelor's degree STEM disciplines at a PUI or TC
- Graduate-level students, who received their undergraduate degree at a PUI or TC and are now enrolled in a master's degree in science education program at NDSU or UND
- Graduate-level students, who received their undergraduate degree at a PUI or TC and are now enrolled in a master's degree in science education program at a PUI
- Graduate-level students, who received their undergraduate degree at a PUI or TC and are now enrolled in a master's degree STEM discipline at NDSU or UND
- Graduate-level students in a master's degree STEM discipline at a PUI or TC

3.8 Focus Area 4-Education and Workforce Development

Strategic Priority: Capitalize on statewide interest in agriculture at all levels of education, while heeding ND's S&T Plan for the ND University System to build capacity in advanced manufacturing and technology based businesses to advance the state's economic vitality.

Goals:

1. Build interdisciplinary STEM research capacity state-wide by engaging and equipping students early in their academic careers (K-12) to be successful in the ND workforce through the expansion of existing group relationships, to leverage the ND EPSCoR investment and reach people from across the state more effectively.

2. Engage graduate students, postdoctoral research associates and faculty associated with the clusters in expanding research and educational opportunities to underrepresented groups and younger learners.

Objectives to Achieve Goals: Increasing statewide interest in preparing a STEM workforce requires a collaborative relationship between research universities, K-12 institutions, groups already engaged with K12 students (*objectives 1.2, 1.3*), and TC and PUI partners (*objectives 1.4, 1.5, 2.2*) to build on early student interests (*objectives 2.1*) and identify (*objectives 1.1*) and address barriers (*objectives 2.3*) to pursuing STEM disciplines.

Team Leads: Education and Workforce Development co-Lead, **Cindy Juntunen** (Interim Dean and Professor, Counseling, UND) serves as the main research liaison from the CRCS group and as the K-12 liaison. The other team co-Lead, **James Nyachwaya**, Assistant Professor, Education and Chemistry/Biochemistry, NDSU) serves as the main research liaison from the CSMS group and as the K-12 bridging and INSPIRE-ND REU Coordinator.

Team Participants:

- **Aaron Bergstrom** (High Performance Computing Specialist, Center for Computational Research, UND) serves as one the teams' two cyberinfrastructure experts.
- **Frank Bowman** (CRCS co-Lead and Associate Professor, Chemical Engineering, UND) serves as an education and workforce development research liaison from the CRCS group.
- **Mark Guy** (Professor, Teaching & Learning, UND) serves as an outreach liaison for K-12 and the general public.
- **Scott Hanson** (ND EPSCoR Tribal Colleges Liaison) serves as the Chair of the EMPOWERED-ND Corps
- **Mark Hoffmann** (ND EPSCoR Associate Project Director and Associate Vice President for Research and Economic Development, UND) serves as a team/EPSCoR leadership facilitator/liaison for the team, specifically its UND members.
- **Ashley Hutchison** (Assistant Professor, Counseling) studies vocational psychology of rural and underrepresented groups.
- **Martin Ossowski** (Director, Center for Computational Assisted Science & Technology, NDSU) serves as one of the teams' two cyberinfrastructure experts.
- **Jean Ostrom-Blonigen** (ND EPSCoR Project Administrator, NDSU) serves as a team/EPSCoR leadership facilitator/liaison for the team, specifically its NDSU members.
- **Mukund Sibi** (CSMS co-Lead and Distinguished Professor, CBC, NDSU) serves as an education and workforce development research liaison from the CSMS group.
- **Timothy Young** (Professor, Physics and Astrophysics, UND) serves as an outreach liaison for K12 and the general public.

- The Education and Workforce Development team will work collaboratively with all other project components.

Key outcomes: 1) Increased number of diverse students are equipped with the skills to address problems relevant to North Dakota; 2) Increased number of students early in their education interested in STEM; and 3) Increased state-wide research capacity.

Table 5. Focus Area 4 Goals, Objectives, Benchmarks and Activities, Output Metrics and Baseline and 5-Year Targets

Goal 1: Build interdisciplinary STEM research capacity state-wide by engaging and equipping students early in their academic careers (K-12) to be successful in the ND workforce and through the expansion of existing group relationships , to leverage the ND EPSCoR investment to reach people from across the state more effectively.					
Benchmarks/ Activities	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**
Objective 1.1: Increase student self-efficacy in STEM. **(Juntunen/Hutchison)**					
Assess preintervention levels of self-efficacy.	Collect and analyze pre-test data for K-12 students in all experiential learning programs. Identity all activities with significant hands-on activities.	Collect and analyze pre-test data for K-12 students in all experiential learning programs.	Ongoing.	Ongoing.	Ongoing.
Implement and assess impact of experiential learning activities.	Identity all activities with significant hands-on activities.	Collect and analyze post-test data for all students in all experiential learning programs.	Ongoing.	Ongoing.	Ongoing.
Assess impact of mentoring on self-efficacy in K-12 students.		Establish mentoring matches with NATURE TAs and graduate students.	Collect and analyze post-test data from mentor pairs.	Ongoing.	Ongoing.
Objective 1.2: Increase student interest in STEM. **(See activity assignments below)**					
Assess preintervention levels of interest. **(Juntunen/ Young/Guy/ Hutchison)**	Collect and analyze pretest data for K-12 students in all STEM enrichment curriculum/ activity.	Ongoing.	Ongoing.	Ongoing.	Ongoing.

Develop a train the trainers/ educators workshop. **(Juntunen/ Guy/ Hutchison)**	Establish partnership with K-12 institutions; implement workshop with Teacher Ed faculty or graduate students.	Complete "training the trainers" activity.			
Deliver STEM enrichment and analyze effect on students in STEM enrichment/ curriculum activity **(Juntunen/Hutchison)**		Implement modules in classrooms and collect and analyze student interest post-test data	Ongoing.	Ongoing.	Ongoing.
Objective 1.3: Increase student intentions to pursue STEM career or major. **(Juntunen/Hutchison)**					
Assess preintervention levels of intention.	Collect and analyze pre-test data for all students in all STEM enrichment programs.	Ongoing.	Ongoing.	Ongoing.	Ongoing.
Implement and assess impact of all STEM enrichment learning activities.	Identity all activities with significant hands-on activities.	Collect and analyze post-test data for all students in all experiential learning programs.	Ongoing.	Ongoing.	Ongoing.
Determine the impact of STEM modeling by advanced students.		Develop CRCS and CSMS science content podcasts by graduate and undergraduate students.	Collect and analyze post-test data after viewing podcasts.	Ongoing.	Ongoing.

Objective 1.4: Build capacity for interdisciplinary research state-wide and initiate collaboration with partner institutions (TCs and PUIs) and sustain research collaborations with TC/PUIs. **(See activity assignments below)**					
Initiate collaboration grants at TCs. **(Juntunen/ Nyachwaya/ Hutchison)**	Ideas for collaboration grant use submitted by UND/NDSU researchers. Host collaboration grant information meetings. Identify researchers.				
Collaboration grants initiated at PUIs. **(Juntunen/ / Nyachwaya/ Hutchison)**	Ideas for collaboration grant use submitted by UND/NDSU researchers and collaboration grant information meetings.	Competitive seed grants for collaborative research grants awarded to PUIs.			
Foster collaboration via regular meetings. **(Juntunen/ / Nyachwaya/ Hutchison)**	Welcome meeting to introduce new collaborators. Convene regular IVN meetings. Promote attendance at state conference.	Convene regular IVN meetings and attendance at state conference.	Ongoing.	Ongoing.	Ongoing.
Collaborative fits identified between UND/NDSU and TC/PUI cluster researchers. **(Juntunen/ / Nyachwaya/ Hutchison)**	Initial research integrations identified.	Collaborative links, such as projects as part of CRCS/CSMS team efforts, enhanced/ adjusted as research matures.	Ongoing.	Ongoing.	Ongoing.
Host HPC Bootcamp for researchers at UND and NDSU. **(Bergstrom/ Ossowski)**	Host HPC Bootcamp each semester for UND and NDSU.	Ongoing.	Ongoing.	Ongoing.	Ongoing.

Objective 1.5: Build capacity for interdisciplinary research state-wide, initiate collaboration with partner institutions (TCs and PUIs) and sustain research collaborations with TC/PUIs. **(See activity assignments below)**					
Outreach Portfolio created and maintained. **(J. Zhang/ Webster/ Hanson/ OstromBlonigen)**	Collect project ideas from outreach coordinators, including (but not limited to) NATURE, Presentations or lesson plan development, community	Update portfolio.	Ongoing.	Ongoing.	Ongoing.
Citizen Science Grid (CSG) and outreach to K-12 through STEM organizations. **(Bergstrom)**	Develop CRCS applications and content for CSG.	Develop CSMS applications and content for CSG and market CSG app/content to K-12 classrooms through Dakota STEM Initiative and programs such as NDSCS 'You're Hired!	Market CSG app/content to K-12 classrooms through Dakota STEM Initiative and programs such as NDSCS 'You're Hired!	Ongoing.	Ongoing.
Sharing of cyberinfrastructure expertise. **(Bergstrom/ Ossowski)**	Hold CI sessions at statewide EPSCoR events.	Ongoing.	Ongoing.	Ongoing.	Ongoing.
General HPC information session for NATURE program. **(Bergstrom/ Ossowski)**	Hold HPC information session for Nature program.	Ongoing.	Ongoing.	Ongoing.	Ongoing.

Goal 2: Engage undergraduate and graduate students, postdoctoral research associates and faculty associated with the clusters in expanding research and provide educational and research opportunities to underrepresented groups and younger learners from other ND institutions.					
Benchmarks/ Activities	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**
Objective 2.1: Increase student intentions to pursue STEM career or major.					
Engage students in research related to cluster foci by establishing and maintaining a summer REU program that includes PUI and TC faculty and students. (**Nyachwaya/ Hanson/ Hoffmann/Ostrom-Blonigen)**	Establish recruitment plan, selection processes. Identify administrative personnel to coordinate recruitment, selection, and logistics.	Administer REU programs based on feedback and increase participation of PUI and TC faculty and students.	Ongoing.	Ongoing.	Ongoing.
Objective 2.2: Engage students from PUIs/TCs in graduate degree programs. **(See activity assignments below)**					
Recruit PUI and TC students into Master's and Doctoral programs at UND/NDSU. **(Juntunen/ Nyachwaya/ Hutchison**)	Establish and implement recruitment plan. Visit PUIs and TCs. Invite PUI/TC faculty to clusters.	Continued recruitment efforts to achieve desired metrics.	Ongoing.	Ongoing.	Ongoing.
Provide financial support for graduate research. (**Nyachwaya/Hanson Bowman)**	Establish criteria for awarding fellowships and identify metrics for adequate yearly progress.	Annual review of fellows' progress.	Ongoing.	Ongoing.	Ongoing.
Objective 2.3: Provide diverse professional development (PD) opportunities for undergraduate and graduate student trainees. **(See activity assignments below)**					
Create a directed mentorship program for graduate student trainees. Create the RPPAC: Research, Policy & Planning Advisory Committee (**Nyachwaya/ Sibi/ Bowman**)	Articulate criteria for and recruit initial RPPAC. Identify list of PD seminars, semester projects for trainees and establish standards for performance.	Provide two seminars per semester. Communicate standards of mastery. Evaluate trainee writing/work. Provide feedback to trainees.	Ongoing.	Ongoing.	Ongoing.

Develop and integrate Science Communication Projects into REU program. **(Nyachwaya/ Bowman/ Hanson/ Ostrom-Blonigen)**	Identify and recruit faculty to facilitate projects. Create science communication guidelines. Identify/create assessment rubrics.	Communicate about Summer Science seminar series. Evaluate REU students' communication products. Disseminate products via Web	Ongoing.	Ongoing.	Ongoing.
Graduate students and postdoctoral researchers will participate in at least one outreach activity per funded semester. **(Juntunen/ / Nyachwaya/ Hutchison)**	Outreach choices okayed and facilitated by outreach coordinator. Students collect and summarize assessment (when applicable).	Ongoing.	Ongoing.	Ongoing.	Graduate students and postdoctoral researchers outreach choices okayed and facilitated by outreach coordinator.
Develop graduate students' skills to conduct education and outreach projects. **(Ulven/ Bowman/ Nyachwaya/ Ostrom-Blonigen)**	Recruit students for NATURE+. Design outreach portfolio. Articulate expectations for graduate student participation in outreach.	Graduate trainees complete at least one project from the outreach portfolio; also collect and report evaluation data relevant for their outreach activity.	Graduate trainees diversify their own education/ outreach experience by completing new opportunities from outreach portfolio.	Ongoing.	Ongoing.
Use HPC bootcamps to train graduate students on HPC basics. (**Bergstrom/ Ossowski**)	Train graduate students.	Ongoing.	Ongoing.	Ongoing.	Ongoing.

Education and Workforce Development Output Metrics

Metric ***(Where baseline data is available, it is represented as an initial measure of this metric; where it is not, the Year 1 projection is used and denoted with an *)***	**Year 1**	**Year 2 (through January 31, 2016)**	**Five-Year Cumulative Targets**
Obtain approval of Institutional/research review boards at the TCs/reservations to collect data from students during the NATURE Sunday Academy sessions	N/A	4	4+ (one TC is not yet governed by an IRB/RRB); if that changes, we will also work with that campus)
Obtain Institutional Review Boards approval from the 2 research universities to collect data during the NATURE Sunday Academy sessions	N/A	2	2
Number of K-12 Sunday Academy students completing Baseline (1-2) Self-efficacy Interests and Values Major/Career Intentions/Goals **(incl. post-test and repeated measures)**	 0 0 0	 100/102 100/102 100/102	 300 300 300
K-12 Sunday Academy students will demonstrate an increase in STEM Self-efficacy on the Lent STEM Self-efficacy Scale @ post-test	N/A		.25 SD increase
Number of 4th/5th grade Rural students completing Baseline Self-efficacy Interests & Values Major/Career Intentions/Goals (incl. repeated measures)	 0 0 0	 100/0 100/0 100/0	 300-450 (M1) 300-450 (M1) 300-450 (M1)
Number of 8th grade Rural students completing Baseline Self-efficacy Interests & Values Major / Career Intentions/Goals (incl. repeated measures)	 0 0 0	 100/0 100/0 100/0	 300-450 (M1) 300-450 (M1) 300-450 (M1)
Number of 4th/5th grade Rural students completing Post-Test Self-efficacy Interests & Values Major/Career Intentions/Goals (incl. repeated measures)	 N/A N/A N/A	 N/A N/A N/A	 300-450 300-450 300-450
Number of 8th grade Rural students completing Post-Test Self-efficacy Interests & Values Major/Career Intentions/Goals (incl. repeated measures)	 N/A N/A N/A	 N/A N/A N/A	 300-450 300-450 300-450
4th/5th and 8th grade Rural student will demonstrate an increase in STEM Self-efficacy on the Lent STEM Self-efficacy Scale @ post-test	N/A	N/A	.25 SD increase

Number of mentor pairs (identified in year 2)	N/A	*0 – currently recruiting*	24
Students in mentoring pairs will demonstrate an increase in STEM self-efficacy on the Lent STEM Self-efficacy Scale @ post-test	N/A	N/A	.50 SD increase
Training of educators to initiate new classroom interventions	N/A	0	8-16
Number of CRCS and CSMS podcasts developed	N/A	0 – *Spring & Summer, 2016*	6-10
Number of high school students completing STEM Major/Career Intentions Scale, following podcast viewing	N/A	0 – *Spring & Summer, 2016*	600-900*
Number of ND undergraduates recruited as REU participants, 70% from TC/PUIs	N/A	5	12-15
Number of PUI/TC students recruited into Master's and Doctoral programs: NASSE	N/A	1	6
Number of Graduate Research Assistantships (GRA) and Doctoral Dissertation Assistantships (DDA) awarded to STEM graduate students: NATURE+	N/A	1	6
Number of seminars provided both in-person and over the web	N/A	CRCS – 8 CSMS – 20	81 (M2)
Number of summer seminar series provided in-person or via web	N/A	0; *Summer 2016*	4
Number of REU participant-generated science communication project created and disseminated via WWW	N/A	0; *Summer 2016*	4-8
Number of electronic outreach portfolios available on cluster websites	N/A	0 – CRCS 0 – CSMS *Summer 2016*	6
Number of graduate students participating in HPC Bootcamps	9	0; *Spring & Summer 2016*	20
Number of informational meetings at TCs	6	9	5
Number of cluster researchers identified at TCs	6	5	>=5
Number of cluster researchers identified at PUIs through collaborative seed grants	N/A	7	>=4
Number of HPC Bootcamps for faculty, staff and students at all locations	2	0; *Scheduled 1 Spring, 1 Summer 2016*	9
Number of TC/PUI participants in cluster group meetings	CRCS – 3 CSMS – 4	CRCS – 6 CSMS – 3	45

Number of TC/PUI faculty attendees at state conference	4	N/A; *April 2016*	45
Number of cluster-related conference presentations including TC/PUI authors	N/A	CRCS – 3 CSMS – 0	17 (M3)
Number of cluster-related publications including TC/PUI authors	N/A	CRCS – 7 CSMS – 0	9
Number of cluster-related proposals submitted including TC/PUI co-investigators	N/A	CRCS – 0 CSMS – 0	15 (M4)
Number of CI Sessions at state-wide EPSCoR Events	1	0; Spring 2016	5
Number of activity ideas included in outreach portfolio	N/A	CRCS – 5 CSMS – 17	50-150
Number of outreach activities completed	CRCS – 2 CSMS – 2	CRCS – 2 CSMS – 0	50-200 (M5)
Number of Citizen Science Grid CRCS and CSMS apps developed	CRCS – 1 CSMS – 0	CRCS – 0 CSMS – 0	2
Number of Citizen Science Grid CRCS and CSMS apps in classrooms	N/A	CRCS – 0 CSMS – 0	21
Number of general HPC information sessions for NATURE program	1	0; *1 Scheduled Summer 2016*	5-10

*These numbers represent 300+ students per year during each of the last three years of the program; individual students may repeatedly participate.

Education and Workforce Development Mitigation Plans, approved by NSF RSV panel:

- M1: In our proposal, we originally expected to reach rural students through 4-H and FFA, because of their unique connection to rural education. However, in a Y1 meeting with 4-H and FFA, we discovered that their resources for these types of collaborations are so limited that such a collaboration would require ND EPSCoR's investment in personnel on their side as well as ours. Thus, we discussed changing our focus to contacting rural schools with our NSF program officer. Seeking to meet the original intent of our proposal: outreach to under-served rural students, we have begun collaborating with the 8 Regional Education Associations (REAs) in North Dakota to bring CRCS- and CSMS-informed interventions directly into the classrooms of rural students. We are targeting 8th grade and 5th grade (in some cases, rural classrooms have combined 4th and 5th grade classes) because those students will be making key STEM-related decisions during the 3 year of this award, including advanced class options, initial college and major choices. Therefore, in keeping with the intent of the proposal (targeting rural K-12 students), the new co-Lead has begun setting a stage for her work with 300-450 rural 4th/5th graders and 300-450 rural 7th graders; for a combined total of 600-900 rural participants.
- M2: The co-Leads will work with the CRCS and CSMS Leads to develop a schedule for seminars that meets this metric.
- M3: TC and PUI members have just begun their research; thus presentations are expected to follow in future years.
- M4: TC/PUI collaborations are growing and including TC/PUI researchers will be a specific focus when preparing funding proposals. Breakout sessions at the 2016 Annual ND EPSCoR Conference (in April) will focus on developing proposal ideas and identifying teams of investigators.
- M5: This metric suffered due to the loss of the leads in this area. Guodong Du (CSMS) and Aaron Kennedy (CRCS) has taken over coordination of outreach activities. Both based on the UND campus, they are now recruiting students for outreach activities and looking for new opportunities.

3.9 Focus Area 5-Partnerships, Collaborations and Communication

Strategic Priority: Create a network of well-informed persons and businesses that not only benefit from the research, but who also can advance the overall knowledge base of the public, in general.

Goals:

1. Develop partnerships with regional industries in value-added agriculture and other enterprises that depend on knowledge of climatic variation and weather extremes.

2. Develop collaboration between the research themes and national labs.

3. Engage students and postdoctoral research associates in partnerships and collaborations.

4. Communicate with stakeholders and public in general to ensure and enhance awareness using more contemporary media, such as webinets, blogs and podcasts, to complement traditional means, such as magazines and newsletters.

Objectives to Achieve Goals: Developing partnerships and collaborations to advance the work of the research clusters into a value-added proposition for ND requires a joint communication effort from the research universities to ND K-12, PUIs, TCs; as well as partnership with other state and federal entities and academic research entities (*objectives 1.1, 2.1*) and those across the NGP who have a vested interest in the science (*objectives 1.2*). Just as students will benefit from relationships with ND industry (*objectives 3.1*), ND industry will benefit from the knowledge of students who are engaged in the research clusters. However, the ultimate success of these research efforts lie with stakeholder and the public in general, who are oftentimes unfamiliar with the research efforts with higher education (*objectives 4.1, 4.2, 4.3, 4.4*); thus these groups must also be called upon to collaborate in these efforts (*objectives 4.5*).

Team Leads: The co-Leads on the CRCS project, **Frank Bowman** (CRCS co-Lead and Associate Professor, Chemical Engineering, UND), and the CSMS project, **Mukund Sibi** (CSMS co-Lead and Distinguished Professor, Chemistry and Biochemistry, NDSU), are also the co-Leads for Partnerships, Collaborations and Communication

Team Participants:

- **Crystal Alberts** (Associate Professor, English and Director of Writers Conference, UND) serves as a communication liaison from the CRCS group.
- **Anne Denton** (Associate Professor, Computer Science, NDSU) serves as a liaison from the CRCS group.
- **Erin Gillam** (Associate Professor, Biological Sciences, NDSU) serves as a collaboration liaison to the TCs/PUIs from the CRCS group.
- **Scott Hanson (**ND EPSCoR Tribal Colleges Liaison – since May 2015) provides liaison expertise between ND EPSCoR, the TCs, and the EMPOWERED-ND Corps for all facets of the program.
- **Mark Hoffmann** (ND EPSCoR Associate Project Director and Associate Vice President for Research and Economic Development, UND) serves as a team/EPSCoR leadership facilitator for the team, specifically its UND members.
- **Alena Kubatova** (Professor and Director of Recruitment, Chemistry, UND) serves as a collaboration liaison to the TCs/PUIs from the CSMS group.
- **Zoltan Majdik** (Associate Professor, Communication, NDSU) serves as a communication liaison from the CRCS group.

- **Jean Ostrom-Blonigen** (ND EPSCoR Project Administrator, NDSU) serves as a team/EPSCoR leadership liaison for the team, specifically its NDSU members.
- **Kelly Rusch** (ND EPSCoR Project Director and Vice President for Research and Creative Activity, NDSU) serves as a team/EPSCoR leadership facilitator for the team.
- **Chad Ulven** (Associate Professor, Mechanical Engineering, NDSU) serves as a liaison from the CSMS group.
- **Dean Webster** (CSMS Director and Professor and Chair, Coatings and Polymeric Materials, NDSU) CSMS Lead
- **Jianglong Zhang** (CRCS Director and Associate Professor, Atmospheric Sciences, UND) CRCS Lead
- The Partnership, Collaborations and Communications team will work collaboratively with all of the other project components.

Key Outcomes: 1) Increased partnerships with companies and national labs to advance CRCS and CSMS science and engineering infrastructure and translational research opportunities; 2) Increased partnerships with industry to advance STEM workforce development and training; 3) Increased public understanding of the scientific and educational programs and benefits of INSPIRE-ND; and 4) People from across ND will provide feedback to ND EPSCoR and pursue mutually beneficial opportunities.

Table 6. Focus Area 5 Goals, Objectives, Benchmarks and Activities, Output Metrics and Baseline and 5-Year Targets

Goal 1: Develop partnerships with regional industries in value-added agriculture and other enterprises that depend on knowledge of climatic variation and weather extremes.					
Benchmarks/ Activities	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**
Objective 1.1: Develop partnerships to advance CRCS and CSMS science and engineering infrastructure and translational research opportunities and specifically Academic/industrial collaborations. **(Ulven/Sibi)**					
Create partnerships with industry through ND Department of Commerce or other similar programs.		Submit Research-ND proposals.	Ongoing.	Ongoing.	Ongoing.
Develop Translational Research Initiative (TRI) program to provide technology proof-of concept funding.	Identify private sector industry partners.	Identify collaboration projects.	Select collaboration projects.	Monitor projects.	Review program.
Collaborate with industry on SBIR/STTR opportunities.	CSMS and CRCS faculty initiate collaborations with industry.	CSMS faculty submit one SBIR/STTR proposal.	Ongoing.	Ongoing.	Ongoing.
Objective 1.2: Develop working relationships with agricultural producers and associated organizations in order to strengthen those associations. **(Denton)**					
Strengthen relationship with American Crystal Sugar Company and develop new partner relationship.	Develop data sharing protocols. Identify areas of interest for partners.	Share science outcomes with producers. Recruit new agriculture group partner.	Ongoing.	Ongoing.	Ongoing.

Goal 2: Develop collaboration between the research themes and national labs.					
Benchmarks/ Activities	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**
Objective 2.1: Establish collaborations with federal research and other academic research entities. **(Sibi, J. Zhang)**					
Participate in observational networks and integrate data into regional climate studies.	CRCS develops climate data partners.	Exchange data with climate partners.	Ongoing.	Ongoing.	Ongoing.
Establish and maintain CSMS-DoE and USDA lab partnerships.	CSMS initiates and tracks contacts with DoE labs and USDA labs.	Exchange ideas with DoE and USDA scientists. Track interactions.	Ongoing. Student internship at DoE and/or USDA labs.	Ongoing.	Ongoing.
Goal 3: Engage students and postdoctoral research associates in partnerships and collaborations.					
Benchmarks/ Activities	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**
Objective 3.1: Collaborate with ND companies to provide students with STEM-related industry experience. **(Webster/Sibi/Bowman)**					
Identify and support summer internships in ND industry.	Identify ND industry partners for student internships.	Ongoing.	Ongoing.	Ongoing.	Ongoing.
Identify and support regional (MN, MT, SD) industry and summer internships.	Develop plan for contacting industries	Identify regional industry partners.	Establish student internships in regional industry.	Review quality and continue.	Ongoing.
Goal 4: Communicate with stakeholders and public in general to ensure and enhance awareness using more contemporary media, such as webinets, blogs and podcasts, to complement traditional means, such as magazines and newsletters.					
Benchmarks/ Activities	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**
Objective 4.1: Improve public awareness of INSPIRE-ND activities. **(/Sibi/Bowman/ Webster/J. Zhang/ Alberts/Majdik/Wahlberg/Rusch/ Hoffmann/Ostrom-Blonigen/Hanson/All program participants)**					
Develop INSPIRE-ND Websites.	Develop website(s) for CRCS and CSMS with video, webinets, etc. to provide easy access to informative and up to date information.	Maintain and enhance an up to-date website. Ensure that information is cross-pollinated to reach a larger audience. Develop new ND EPSCoR website.	Ongoing.	Ongoing.	Ongoing.

Publicize ongoing INSPIRE-ND results and achievements.	Establish website news category. Maintain e-mails to all (NDSU, UND, PUIs TCs). Create blogs by students, faculty on scientific accomplishment and news from ND EPSCoR.	Publish and distribute a yearly electronic newsletter. Create blogs by students, faculty on scientific accomplishment Include news from ND EPSCoR personnel on accomplishment	Ongoing.	Ongoing.	Ongoing.
Identify, pursue and develop opportunities for media cross-pollination and coverage.	Create podcasts using local broadcasting or other media and create webinets on INSPIRE-ND websites.	Use print and radio/television to disseminate progress and promote story ideas to students	Ongoing.	Ongoing.	Ongoing.
Define a media/ publication monitoring system to measure coverage by online, newspapers and broadcast media.	Develop web usage statistics. Track articles and reports on CRCS, CSMS, and other ND EPSCoR accomplishments	Continue monitoring web, print, broadcast statistics.	Ongoing.	Ongoing.	Ongoing.
Develop social media toolkit.	Hold workshop (NSF style) on how best to use social media to promote science.	Create web modules on communication skills.	Hold Social Media Workshop.	Ongoing.	Ongoing.
Objective 4.2: Improve awareness of CRCS and CSMS scientific research and integrated education programs to multiple audiences. **(Sibi/Bowman/ Webster/J. Zhang/Alberts/Majdik/Wahlberg/Rusch/ Hoffmann/ Ostrom-Blonigen/Hanson/All program participants)**					
Participate in Science Cafes.	Discuss grand challenges to general public in an open science café format.	Ongoing.	Ongoing.	Ongoing.	Ongoing.

Publicize ongoing CRCS and CSMS activities on Center websites.	Develop websites for CRCS and CSMS with more detailed science content than on general INSPIRE-ND website.	Maintain up to date websites for CRCS and CSMS. Organize annual in-house seminar series at NDSU and UND to promote sustainability and showcase the research themes.	Ongoing.	Ongoing.	Ongoing.
Disseminate scientific accomplishment using a variety of media tools.	Disseminate scientific accomplishment using a variety of media tools.	Ongoing.	Ongoing.	Ongoing.	Ongoing.
Objective 4.3: Generate public interest in STEM to augment success of EMPOWERED-ND programs. **(Hanson /Alberts/Majdik/All program participants/Rusch/Hoffmann/Ostrom-Blonigen)**					
Promote EMPOWERED-ND activities; develop press releases, engage in media interviews, invited talks and speaking engagements.	Use ND EPSCoR, CRCS and CSMS websites to promote outreach activities. Post videos and webinets on outreach activities.	Ongoing. Send mass e-mail mailing of yearly newsletter.	Ongoing.	Ongoing.	Ongoing.
Objective 4.4: Inform stakeholders of INSPIRE-ND projects, activities, and achievements (the target stakeholder groups are identified within the activities). **(Sibi/Bowman/ Webster/J. Zhang/ Alberts/Majdik/Wahlberg/ Rusch/Hoffmann/Ostrom-Blonigen/Hanson/All program participants)**					
Prepare INSPIRE-ND Annual Report.	Prepare individual progress reports from CRCS, CSMS, outreach and educational activities.	Ongoing. To include Y2 NSF Reverse Site Visit.	Ongoing.	Ongoing. To include Y4 NSF Reverse Site Visit.	Ongoing.
Presentations to stakeholder groups.	Leadership/ faculty visit TC/PUIs; ND EPSCoR leadership visits with legislators. Hold on-campus open forums about how grand challenges are being addressed.	Continue visits and forums. Visit community and, industry groups with targeted presentations on INSPIRE-ND, highlighting opportunities for participation.	Ongoing.	Ongoing.	Ongoing.

Objective 4.5: Provide opportunities for collaborative discussions and feedback from stakeholders. **(All program participants/Rusch/Hoffmann/Ostrom-Blonigen/Hanson)**					
Host Annual ND EPSCoR Conference that includes poster and oral presentations by students and faculty, and other sessions e.g., café-like presentations by faculty; breakout session with small working groups	Students and faculty prepare presentations. Review feedback from previous conference; planning committee meets to make arrangements; discuss issues, accomplishment and course of action.	Ongoing.	Ongoing.	Ongoing.	Ongoing.
Host External Advisory Board (EAB) Meetings and develop Annual Reports.	Prepare oral and poster sessions by students and faculty; hold Q&A sessions between faculty and EAB.	Ongoing.	Ongoing.	Ongoing.	Ongoing.
Host community, school, and industry group meetings.	Identify groups to visit and topics of interest and develop feedback mechanisms for community meetings.	Include mechanisms to elicit feedback in community meetings.	Ongoing.	Ongoing.	Ongoing.

Partnerships, Collaboration and Communication Output Metrics

Metric ***(Where baseline data is available, it is represented as an initial measure of this metric; where it is not, the Year 1 projection is used and denoted with an *)***	**Year 1**	**Year 2 (through January 31, 2016)**	**Five-Year Cumulative Targets**
Number of Research ND proposals submitted	N/A	1	4
Number of translation research initiatives at $10,000 each	N/A	CRCS – 3 CSMS – 2	6
Number of SBIR/STTR proposals submitted	N/A	CRCS – N/A CSMS – 3	4
Number of climate data partners	N/A	CRCS – 1 CSMS – N/A	5 (M1)
Number of DoE and USDA Lab partners	N/A	CRCS – N/A CSMS – 1	10 (M2)
Number of DoE Lab student internships	N/A	CRCS – N/A CSMS – 0	5 (M3)
Number of agricultural group partners	N/A	CRCS – 3 CSMS – N/A	12
Number of ND industry partners	N/A	CRCS – 2 CSMS – 3	8
Number of student interns (ND)	N/A	CRCS – 0 CSMS – 1	13 (M4)
Number of regional industry partners	N/A	CRCS – 1 CSMS – 0	5
Number of student interns (regional)	N/A	CRCS – 0 CSMS – 0	6 (M5)
% New content added to website	CRCS – 100% CSMS – N/A ND EPSCoR – N/A	CRCS – 20% CSMS – 100% ND EPSCoR – *Y2 go live*	Base +75%
Number of visits to website	N/A	CRCS –1799 CSMS – 414 ND EPSCoR – *Y2 go live*	4400 (M6)
Number of news items posted to the website	CRCS – 0 CSMS – N/A	CRCS – 0 CSMS – 10	47
Number of blog entries	N/A	CRCS – 0 CSMS – 2	22 (M7)
Number of media outlet reports	N/A	CRCS – 0 CSMS – 2	23 (M8)
Number of in-house seminar series	N/A	CRCS – 1 CSMS – 1	4+
Number of Science Café events	CRCS – 1 CSMS – N/A	CRCS – 0 CSMS – 0	8 (M9)
New content added to CRCS & CSMS websites	N/A	CRCS – 15 CSMS – 84	175

Number of visits to websites	N/A	CRCS – 1799 CSMS – 414	2200 (M10)
Number of EMPOWERED-ND publicity items (e.g.: video, blogs, print)	N/A	6	36
Annual Report published	1	0; *May 2016*	5
Number of TC/PUI visits	CRCS – 5 CSMS – 3 TC Liaison Manager – 5	CRCS – 0 CSMS – 2 TC Liaison Manager – 5	10
Number of legislator visits	1	1	9
Number of campus open forums	N/A	CRCS – 0 CSMS – 1	9 (M11)
Number of community/school/industry group visits	N/A	CRCS – 1 CSMS – 2	7 (M12)
Annual conference held	1	0; *April 2016*	5
Number of external advisory board meetings	1	1	5

Partnerships, Collaborations and Communication Mitigation Plans, approved by NSF RSV panel:

- M1: CRCS is in the process of identifying potential partners, making contacts and setting up visits.
- M2: CSMS is in the process of identifying potential partners, making contacts and setting up visits to labs.
- M3: CSMS will identify internship opportunities with DOE labs, post on website, and inform students.
- M4-5: ND personnel participated in the two-part NSF workshops: *Innovation, Entrepreneurship, and Translational Research.* As a result, the team is working to develop an Action Plan Worksheet for Partnerships, Collaborations and Communication Goals 1 and 3 has been developed.
- M6: See attached Audit of ND EPSCoR Track-1 Websites: ND EPSCoR will begin tracking this metric when our new site is live and CRCS will begin tracking this metric and publish it on their website by May 1, 2016
- M7-12: See attached Audit of ND EPSCoR Track-1 Websites:
    - CRCS will:
        - Create a blog on their website by May 1, 2016 (M7)
        - Collect and post past reports on their website by May 1, 2016 (M8)
        - Begin tracking this metric and publish it on their website by May 1, 2016 (M10)
        - Visit one community/school/ industry group and post it to their website by May 1, 2016 (M12)
    - CRCS and CSMS will each host:
        - Host one Science Café and post it to their websites by May 1, 2016 and at least one Science Café and post it to their websites each year thereafter (M9)
        - Host one campus open forum and post it to their website by May 1, 2016 and at least one campus open forum and post it to their websites each year thereafter (M11)
        - Visit on community/school/ industry group and post it to their websites each year thereafter (M12)

3.10 Cyberinfrastructure

INSPIRE-ND's Cyberinfrastructure Plan [CI] is embedded across three of the five Focus Areas. Individual benchmarks/activities are incorporated into each of the relevant tables in an effort to ensure integration of CI throughout the project.

Goal: The goal of the CI activities under this EPSCoR project is to support activities of the two research clusters as well as to provide opportunities for outreach and sharing of CI expertise in the area of advanced and High Performance Computing (HPC). The Strategic Planning Meeting (SPM) held on October 20-21, 2014 introduced some changes to our CI Plan. In particular, the use of dedicated Cloud Object Storage system, which was a part of our original CI Plan, was meant to provide a data transfer facility that would provide novice and seasoned end-users of our HPC systems with means to easily and efficiently transfer large amounts of data between UND and NDSU. However, in discussions with our EPSCoR research cluster teams and with other North Dakota EPSCoR team members during the SPM it was determined that the emphasis of the CI activities should be shifted toward providing additional training in general HPC and consequently that funds originally allocated for the acquisition of a dedicated Cloud Object Storage system ought to be repurposed toward that training and toward broader HPC outreach. Similarly, it was determined that in order to save additional funds for these activities the research cluster teams should primarily rely on a local storage and a local Relational Database Management system (RDBMS) minicloud at NDSU rather than on extended use of public repositories development of novel data warehousing platforms (which would have necessitated expensive efforts related to development of data integration and cloud interoperability technologies).

The two institutions already have experience with Globus Online implementation of the GridFTP protocol and with the conventional Secure Copy Protocol (SCP) for data movement. As such, we also determined during the SPM meeting that the nature and the amount of data that is planned to be exchanged between NDSU and UND is expected to lend itself well to these technologies. Combined with planned enhancements to our local storage systems, this reduces the need for deployment of the above mentioned dedicated Cloud Object Storage infrastructure. With regard to the proposed RDBMS minicloud infrastructure at NDSU, it was determined during the SPM that such facility will satisfy the needs of the CRCS research cluster. NDSU has the necessary knowledge and experience to architect, build, and maintain the RDBMS minicloud for this EPSCoR project. The changes described above to the CI Plan will therefore not affect our ability to fulfil the original objectives of this EPSCoR project while enhancing our ability to provide additional HPC training, education, and outreach activities.

Team Leads: Martin Ossowski (Director, Center for Computationally Assisted Science and Technology (CCAST)-NDSU)) and Aaron Bergstrom (HPC Specialist, Computational Research Center (CRC), UND).

Team Participants: the point-of-contacts for cyberinfrastructure are the Team Leads for the three focus areas.

Embedded Cyberinfrastructure Activities:

1. Develop an efficient implementation of the Globus Online GridFTP data transfer tool (*Focus Area 1, Goal 2, Objective 2.2 and Focus Area 2, Goal 2, Objective 2.5*).
2. Architect and build local Relational Database Management system (RDBMS) minicloud at NDSU in support of collaborative activities within the UND CRCS research cluster, possibly housed at NDSU CCAST, possibly housed elsewhere (*Focus Area 1, Goal 2, Objective 2.3*).

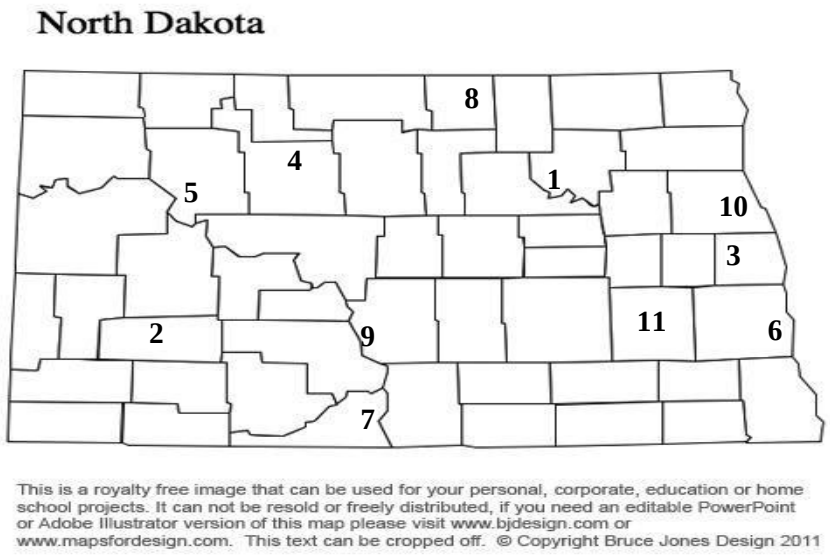
3. Procure a limited amount of HPC enhancements needed by both research clusters for modeling, simulation, visual analysis and storage (*Focus Area 1, Goal 2, Objective 2.4 and Focus Area 2, Goal 2, Objective 2.6*).
4. Host HPC outreach activities as needed and outlined within the tables above (*Focus Area 4, Goal 1, Objective 1.4*).
5. Sharing of cyberinfrastructure expertise (*Focus Area 4, Goal 1, Objective 1.5*).
6. General HPC information sessions for NATURE program (*Focus Area 4, Goal 1, Objective 1.5*).
7. Train graduate students on HPC basics (*Focus Area 4, Goal 2, Objective 2.3*).

There will be **two general outcomes** of the CI plan. First, through activities within the two research clusters, it will implement strategic enhancements in: (1) Data processing capabilities, (2) Data storage and movement capabilities, and (3) Database technology and its implementation in a cloud/virtual environment. Second, through its Education and Workforce Development activities it will increase awareness of the role of CI among the state's K-12 students and provide opportunities for outreach and sharing of CI expertise in the area of advanced and high performance computing among the state's college students.

3.11 Synergies for Sustainability

Demonstrated throughout this strategic plan are statewide synergistic prospects that will result when the efforts of ND researchers (students (graduate and undergraduate) and faculty) located at institutions of higher education (see map) throughout the state are combined in ways that seek to develop **E**merging **P**r**O**grams for **W**orkforc**E** Development, Out**R**each, **E**ducation and **D**iversity in **ND** (EMPOWERED-ND) and serve to sustain our research efforts.

1. Cankdeska Cikana Community College (CCCC), Fort Totten
2. Dickinson State College (DSC), Dickinson
3. Mayville State University (MaSU), Mayville
4. Minot State University, (MiSU), Minot
5. Nueta Hidatsa Sahnish College (NHSC), New Town
6. North Dakota State University (NDSU), Fargo
7. Sitting Bull College, SBC, Fort Yates
8. Turtle Mountain Community College (TMCC), Belcourt
9. United Tribes Technical College (UTTC), Bismarck
10. University of North Dakota (UND), Grand Forks
11. Valley City State University, (VCSU), Valley City



Throughout the ND Strategic Plan, the highlighted metrics that are contained in each of the individual Focus Areas represent the sustainability components of the INSPIRE-ND program. As depicted in the map above, the distance between the state's public institutions combined with the difficulties associated with winter travel make collaboration challenging. This program seeks to build on collaborative research programs, like CRCS and CSMS, by using infrastructure investments NSF has already made in the state (e.g.: C-2) to provide an EMPOWERED-ND built on diversity, education, outreach, and workforce development that uses all these synergies for the sustainability of ND's research programs.

3.12 Risk Mitigation Plan

During the Strategic Planning Workshop, project members were asked to consider all potential risks to the program and associated consequences: Each of the five group leads worked with their teams to identify risks and consequences, as well as the ideas for mitigation. This process resulted in the Risk Mitigation Matrix (Table 7).

Table 7. Risk Mitigation Matrix

No.	Potential Risks	Consequences	Impact	Likelihood	Mitigations
1.	Too many tasks to complete in the timeframe allocated	May need to redesign/adjust composition of project; delay in meeting ultimate project goals	High	High	Project team to communicate frequently and early-on if there are concerns related to project success
2.	Inability to find TC & PUI faculty who are able to find research time in their schedules	Inability to fully engage the TCs and PUIs at the levels budgeted; thus unable to achieve our workforce development goals	High	Moderate	Continue to communicate with TCs and PUIs; also request Tribal Colleges Liaison to follow-up with faculty on the TCs and work with the NDUS for PUI participation
3.	Insufficient appropriate faculty resources at the TCs and PUIs to engage in the research clusters	No TC or PUI participation	High	Low	Project faculty could engage TCs and PUIs by other means
4.	Decline or discontinuation of state support during the 2015, 2017 or 2019 legislative sessions	Decline in the ND EPSCoR state cash commitment of $4M	High	Low	Continue to communicate ND EPSCoR program outputs and outcomes to ND legislators
5.	Challenges associated with complete degradation of composites	May need to redesign/adjust composition of polymer matrix system; delay in meeting ultimate project goals	High	Low	Seek to anticipate challenges up front. Study degradation of polymer system alone. If needed, redesign polymer system
6.	Inability to recruit and fill Tribal Colleges Liaison position	No Liaison	High	Low	Work more closely with existing TC site coordinators and administration
7.	Inability to find PhD and MS students for NATURE+	No student participation; lessen the potential for workforce development	Moderate	Moderate	None
8.	Too few farmers participate in focus groups	Limited themes emerge; weaker item pool for quantitative survey	Moderate	Moderate	Work with influential colleagues; conduct individual interviews if necessary to replace or augment focus group data
9.	Low response rate to quantitative survey (< 20%)	Limited data; insufficient data to inform models about farmer-level inputs	Moderate	Moderate	Several waves of data collection identified; if sample is not representative, will use statistical weighting models

10.	Insufficient computing resources	Limited modeling capability; modeling efficiency and resolution	Moderate	Moderate	Lower resolution and/or combine separate modeling for different domains
11.	Unavailability of some data for modeling	Limited data; modeling of the related processes	Moderate	Moderate	Estimate or use some reference data
12.	New collaborative proposals not funded	May limit ability to sustain the program	Moderate	Moderate	Engage consultants during proposal writing process for timely feedback to increase chance of program success. Engage program officers ahead of proposal submission to understand program expectations. Submit proposals in a timely fashion to allow for time to resubmit if initial proposals are not funded
13.	A researcher becomes unable to contribute to project due to illness or departs university	Unable to meet metrics	Moderate	Moderate	Shift some work to another peer investigator. Bring on an additional investigator through a seed grant proposal. Initiate a new faculty search for a replacement, if needed
14.	Unable to attract highly qualified and productive postdocs and graduate students	Negative impact on productivity. Hinders ability to meet metrics	Moderate	Low	Actively recruit postdocs from targeted research groups. Actively recruit graduate students with strong backgrounds in undergraduate research
15.	Inability to hire the expertise in a timely manner (e.g., computer programming)	Delay in model development and computer coding	Moderate	Low	Hire postdoc and collaborate with others
16.	Malfunction and possible loss of some field instruments	Limited data for dataset; model calibration and validation	Moderate	Low	Increase field check and maintenance protocols; select secure sites
17.	Some research model developments are delayed	Delayed integration process	Moderate	Low	Study key research subcomponents from both statistical- and modeling based approaches from different investigators. Synthetic data will be created to facilitate the integration step
18.	Inability to identify American Indian advisors in STEM disciplines	Support for American Indian students at the university will be limited	Moderate	Low	University faculty would need to commit more time to better engage TCs students at each university

19.	Monomer targets cannot be synthesized	Monomer not available for polymer synthesis; delay in project progress	Moderate	Low	Work on a number of synthesis targets in parallel. Explore alternate synthesis strategies, use alternate monomers
20.	Spring river flooding shuts down NDSU or UND	Research work delayed	Moderate	Low	Increase effort after normal operations resume
21.	Insufficient physical infrastructure at partner institutions	Barrier to collaborative work	Moderate	Low	ND EPSCoR will continue to work with the TCs and PUIs in this regard
22.	Small amount of yield data from farmers	Small amount of training data for data mining models; limited ability to test algorithms for weather conditions of future years	Moderate	Low	Use existing data and future public data
23.	Dependence of major crop acreages on climate may not be statistically discernible separately from economic and agronomic variables due to statistical confounds, such as multicollinearity	The results would be less interesting, as the effects of climate change on agricultural production is the motivator for this study; publication of results in top tier journal would be more difficult. Forecasting will still be possible even if the effects are not statistically separable	Moderate	Low	Analyze data at a finer scale and draw inferences based on sub-state variation in climate rather than climate change over time
24.	Dependence of field level crop rotation selection on climate variables may not be statistically separable from the effects of market and agronomic variables	The results would be less interesting, as the effects of climate change on agricultural production is the motivator for this study; Publication of results in top tier journal would be more difficult. Field level crop selection can still be forecasted even if the effects of climate change are not statistically separable	Moderate	Low	Make statistical inferences based on spatial variation in climate, controlling for site specific factors like soil type

25.	Inability to recruit Master's and Ph.D. students from in-state	Inability to fully engage the TCs and PUIs at the levels budgeted	Low	Moderate	Continue to communicate with TCs and PUIs; also request Tribal Colleges Liaison to follow-up with students on the TCs and work with Graduate Schools at NDSU and UND
26.	Inability to recruit REU students from in-state	Inability to fully engage the TCs and PUIs at the levels budgeted	Low	Moderate	Continue to communicate with TCs and PUIs; also request Tribal Colleges Liaison to follow-up with students on the TCs
27.	Inability to find undergraduate (UG) researchers from TCs and PUIs to engage in the research clusters	No TC or PUI participation	Low	Low	Continue to communicate with TCs and PUIs; also request Tribal Colleges Liaison to follow-up with students on the TCs
28.	Inability to find American Indian students for research clusters	No student participation in research groups; reduction in relationship between research clusters and NATURE	Low	Low	Continue to communicate with TCs and PUIs; also request Tribal Colleges Liaison to follow-up with students on the TCs
29.	American Crystal Sugar Company (ACSC) stops sharing their data	Input data limited to what is available at that time; data can be used for training but not for testing on new years	Low	Low	Most questions can be addressed based on already available ACSC data and new public data

3.13 Management and Succession Plan

Team Leads: Rusch, Hoffmann, Ostrom-Blonigen

ND EPSCoR Office: offices at both North Dakota State University (NDSU) in Fargo, ND and at the University of North Dakota (UND) in Grand Forks, ND. Kelly Rusch, the NDSU vice president for research and creative activity serves as the ND EPSCoR project director. Barry Milavetz, the UND interim vice president for research and economic development chairs the ND EPSCoR Steering Committee. ND EPSCoR leadership staff are also located at both UND (Mark Hoffmann, associate project director) and NDSU (Jean Ostrom-Blonigen, project administrator).

Management Structure: The ND EPSCoR Director (Rusch), Associate Director (Hoffmann), Project Administrator (Ostrom-Blonigen) and the EPSCoR Office team (Jung, Kellner, Lerud, Slicer, TC liaison (Hanson), project assistant (Wahlberg)) will oversee the implementation of INSPIRE-ND. They will work with the Team Leads of the five goals to ensure timely execution of project components and delivery of outcomes. The EPSCoR Office Team will coordinate project management, data gathering for reports, global event planning. The Team Leads of the five goals will ensure the strategic priorities of the grant are met.

Succession Plan: The purpose of the Succession Plan is to ensure that the leadership and management of program are in place for the duration of the project. The succession plan for all four leadership and management levels listed in Table 8 will be reviewed and updated annually.

Table 8. Succession Strategies

Position	Strategies
PI / ND EPSCoR Project Director	Following a formal search, the NDSU president will name a replacement. From the time of vacancy until the formal search is completed, the NDSU president will appoint an interim replacement. The selected finalist will be vetted with the ND EPSCoR State Steering Committee and the head of the NSF EPSCoR Office.
Co-PIs / Associate Project Director and Project Administrator	Co-PI will inform PI that he/she will be leaving as soon as possible and replacements will be suggested and discussed with PI and other Co-PI. Vetting for a replacement Co-PI will be among those who are already involved in the program and who have the skills and time to provide program oversight. Once a replacement has been identified and accepts the position, a formal "change of Co-PI" request will be made to NSF. Once the change is approved by NSF, the replacement will shadow the Co-PI who is leaving for as long as possible prior to the Co-PI's departure date.
Research Center Component Leads	Each research center has designated a co-lead who assume the leadership role during any planned or unplanned absences of the component lead. In the event that the absence is greater than one month, a second interim co-lead will also be named.
Benchmark/ Activity Leads	Succession planning is not an issue as most benchmarks / activities have two individuals named for backup and collaboration between the two campuses; however, in the event that the individuals named are from different campuses, the project research cluster members will assist with collaboration efforts. In the instances where just one benchmark / activity lead is named, the component lead for that portion of the project will name an interim benchmark / activity lead.

3.14 Evaluation and Assessment Process

The project's evaluation and assessment process will measure program impacts and achievements as outlined for each focus group in the preceding tables. The project management team will use the evaluation results and evaluators' recommendations to inform changes to North Dakota's Track-1 project. The evaluation process utilizes the services of:

- An *External Advisory Board (EAB)* composed of national experts who will meet twice annually (once in person) to review: (1) the progress of the research focus areas and the research competitiveness of participants, (2) the effectiveness of EMPOWERED-ND activities, and (3) ND EPSCoR's management performance. EAB input will enable mid-course changes and informed response to emerging opportunities. The annual EAB report will be provided to the NSF PD.
- A North Dakota-seasoned *External Evaluator* who will: assist with completion of institutional review board protocols; prepare quarterly reports; and meet with the management team and advisory committee to discuss progress, outcomes, and recommendations for improvement.

The evaluation and assessment process includes:

- **Initial evaluation.** The evaluator has worked with the management team throughout the strategic planning process and provided feedback as metrics were developed.
- **Constructive evaluation**. The evaluator will provide periodic feedback to the management team throughout the duration of the project.
- **Final evaluation.** The evaluator will conduct a final assessment of the project/program to determine whether achievement metrics were attained and render an opinion on those that were not.

For the evaluation and assessment process, ND EPSCoR will utilize six evaluation and assessment mechanisms: (1) a strategic plan and evaluation plan, (2) staff time dedicated to data collection, coordinating and reporting, (3) a tribal colleges liaison, (4) an annual meeting of the EAB of independent experts to provide guidance and feedback, (5) an external independent evaluator, and (6) a feedback loop to ensure appropriate and timely management responses.

4. APPENDICES

4.1 Programmatic Terms and Condition Resolution: CRCS –Research Plan
4.2 Programmatic Terms and Condition Resolution: CSMS-Hiring Plan
4.3 April 22, 2016 - NSF RSV recommendations
4.4 May 20, 2016 - ND EPSCoR response to NSF RSV recommendations
4.5 June 22, 2016 – NSF acceptance of ND EPSCoR RSV response #3 and request for additional information related to #1, #2 and #4
4.6 July 29, 2016 – Additional ND EPSCoR Response to RSV #1, #2, and #4
4.7 September 9, 2016 - NSF acceptance of ND EPSCoR RSV response #1, #2, #4 and revised Strategic Plan

APPENDIX 4.1: Programmatic Condition Resolution: CRCS–Research Plan

NSF's programmatic condition #8 address specific jurisdiction terms and conditions. The CRCS responds to Question #8.1: Develop a detailed research plan for the CRCS research theme that delineates the relationships between the subprojects. The plan must be submitted to NSF EPSCoR along with the required RII Strategic Plan:

a) How will farmers be involved in the research?

CRCS Response: Year 1 - Farmers will be invited to participate in focus groups designed to assess their essential understanding of and concerns related to regional climate change. They will also be asked open-ended questions about how their farming practices have changed over time, and how they anticipate them changing in the future. These two sets of questions are intentionally broad, so that farmer-generated themes can in turn emerge to support the development of a quantitative survey instrument in Year 2. In addition to broad queries around these two general areas, a final focused set of questions posed to farmers will investigate the ways in which they make connections between climate change and farming decisions. For this phase of this study, the goal is to complete 8 - 12 focus groups, with 4 - 8 members each. These groups will be convened across the state, using the 8 regions of the state as geographies to delineate pools for participants for inclusion in the invitation to each group. Recruitment of participants will continue until themes are saturated, using standard qualitative research methodologies. In the event that we are not able to engage or form enough focus groups, we will conduct qualitative interviews with individual farmers (in person, or via telephone or video conference), again until a sufficiently large representative group is chosen from each region. It is expected that this phase of the study will involve input from at least 36 farmers, representing both farm and ranch operations, small and large operations, and various crop types.

Years 2 - 5 - Farmers will be surveyed, using the quantitative measure developed from Focus Groups in year 1, regarding their attitudes, behaviors, and decision-making strategies related to crop selection and other farming activities. The survey will also measure attitudes, knowledge, and salience of climate information. Associations between these two constructs will be analyzed individually, and will also be fed into the models being developed in RA 4 & RA 5. For these surveys, representative samples of farmers will be sought in each of the following categories:

- Ranchers in oil-bearing country - by North and South
- Ranchers with no oil - by state quadrants (N, S, E, W)
- Grain farmers in oil-bearing country (N & S)
- Grain farmers with no oil (N, S, E, W)
- Root farmers
- Livestock producers other than ranchers

Across each category, farm operation size will be controlled and samples will be weighted consistent with sampling/survey procedures recommended by Mann and Chowhan (2011).

b) What will be the process for installing sensors on farm equipment?

CRCS Response; As a part of a Partnership or Innovation grant we have a collaboration involving NDSU Soil Science and Extension professor David Franzen and a company from which he has long used sensors, Holland Scientific. This collaboration provides us with access to data from Holland Scientific's Crop Circle sensors. The sensor data holds similar information to remote sensing, but its active sensing technology results in somewhat higher quality and higher resolution than the passive sensing from satellites. The collaboration enables us to work with farmers in contexts where the

farmers' payoff comes from Dr. Franzen's research and Extension activities. A positive side-effect of using these existing relationships is that the timescales on which farmers can receive actionable feedback from Extension activities tend to be shorter than those for climate research and more conducive to maintaining such farmer relationships.

c) What role, if any, will farmers play in the research on autonomous adaptation?

CRCS Response: Firstly, data gathered from farmers (as described above) will be entered into the models. In addition, we work together closely with Extension specialists John Nowatzki (Agricultural Engineering) and David Franzen, both of whom lead many workshops for farmers and agronomists as part of their Extension activities. They also interact with farmers as part of their research. David Franzen has offered to facilitate an addition of questions to questionnaires that are annually sent out to farmers through growers associations. These questionnaires reach many farmers and enjoy high response rates. NDSU Extension services have a long history of establishing close relationships and gaining the trust of farmers throughout the state.

d) How will feedbacks between autonomous farmer activities and regional climate be addressed?

CRCS Response: This question will be addressed with respect to land use and land change (LULC). Autonomous farmer activity related land use and land change (LULC) will be studied using an individual based economic land-use model. The identified LULC will be used to further a study on water resources, evaluate possible feedback on the hydrological cycle, as well as conduct an exploratory study to investigate the impacts of LULC on regional cloud climatology.

The impact of the identified LULC on water resources and the regional hydrological cycle will be simulated using the local/regional models to be developed. In particular, we will examine the impact on water quality, such as fertilizer leaking, and water balance, such as evapotranspiration and runoff. The effect of LULC will also be evaluated by examining changes in evapotranspiration, which will be measured using a scintillometry method and modeled.

Feedbacks to regional cloud climatology will be explored through model simulations with the WRFChem model to investigate linkages between surface emissions, atmospheric chemistry, and cloud formation. Predicted climate-induced changes in land use and crop selection (from RA-5) will be used to define model input scenarios based on published results. Simulations will examine the impact of land use changes and the sensitivity of model predictions to various CCN parameterizations and cloud modeling approaches. As an exploratory study, by integrating with planned aerosol chemistry research, aerosol modeling research, and an improved hydrological observation network, our goal is to achieve an improved insight into modeling based uncertainties of the effects of LULC on regional cloud climatology.

APPENDIX 4.2: Programmatic Condition Resolution-CSMS Hiring Plan

NSF's Jurisdiction Specific Terms and Conditions #8.1: A hiring plan for the CSMS research theme that clearly outlines the plans for hiring four new faculty members in: 1) synthetic organic or inorganic chemistry; 2) computational polymer science; 3) coatings and polymeric science; and 4) polymer and materials LCA, including a detailed timeline. The plan should include risk management in the form of alternatives or mitigation strategies to achieve the research goals in the event that not all of the hires are retained as planned. The hiring plan must be submitted to NSF EPSCoR along with the required RII Strategic Plan:

CSMS Faculty Hiring, Recruiting, and Mentoring Plan

Executive Summary

The Departments of Chemistry and Biochemistry (CHEM) and Coatings and Polymeric Materials (CPM) and the Center for Sustainable Materials Science (CSMS) plan to hire four new faculty members as indicated in the table below.

Department	Rank	Target Start	Research Area
CHEM	Assistant Professor	Fall 2015	Synthetic Materials Chemistry
CPM	Assistant Professor	Fall 2015	Bio-based Polymer Synthesis
CPM*	Assistant Professor	Fall 2016	Computational Polymer Science
CPM**	Assistant or Associate Professor	Fall 2016	Life Cycle Assessment

For each hire, the search will be initiated in the fall semester prior to the intended start semester. A target list of research groups will be prepared for each search for focused recruiting.

*[7/17/2016 Update: Interviews have been completed for the Computational Polymer Science position and an offer was being extended, but turned down. Search committee is considering alternative candidates.]
**[7/17/2016 Update: An offer has been extended for the Life Cycle Assessment position and negotiations are underway]

Goals and Metrics

A new faculty member at the assistant professor level will require time and mentoring to reach a level of research productivity required by the CSMS program. Progress toward success will be continually evaluated with the following goals in mind:

- *Anticipated proposal submissions*
  NSF CAREER (SEES Directorate), DoE, USDA, USB
  Joint collaborative proposal with other CSMS participants by year 4
- *Anticipated publications*
  Two publications from NDSU work by year 2
  Collaborative joint publications with other CSMS participants by year 4
- *Presentations*
  Invited presentations at other institutions (seminars, conferences, etc.)
  Contributed presentations at national/international conferences

Salary Requirements
Three positions will be offered at the assistant professor level. One position will be offered at either the assistant or associate professor level. NDSU is committed to providing nationally competitive salaries for these positions.

Startup Requirements
In order to be competitive and recruit the level of talent that the program requires, and to ensure that each new faculty member will be on solid footing for future success, a competitive startup package is required. Undoubtedly, candidates for this position will be highly sought after by top universities across the country. Personnel costs are the majority of startup funds. This includes summer salary for the PI, graduate research assistants and postdoctoral fellows. Travel funds are also needed so the faculty member can attend scientific meetings and visit program officers prior to proposal submission. For the faculty members involved in experimental studies, funds to purchase lab equipment and supplies are also needed. A competitive startup package over three years will be required to successfully recruit and ensure the success of high quality new faculty members in the areas of materials synthesis and bio-based polymer synthesis. The faculty members involved in computational polymer science and life cycle assessment will have similar requirements for personnel and travel funds. In addition, they will need funds to purchase computer equipment and specialized software for their research efforts. Startup funds will come from the departments, the college, and the provost. The EPSCoR program will provide supplemental funds, if available and where appropriate.

Recruiting and Hiring Plan
The Departments and the Center for Sustainable Materials Science (CSMS) will conduct national searches for each new faculty member. The Departments will cover the anticipated costs for conducting the faculty search and hiring. The position will be advertised nationally and internationally in *Chemical and Engineering News*, *Science*, on the NDSU web page, and through targeted emails and letters to chairs and faculty in the targeted research groups and others as well as relevant listservs. The advertising campaigns will commence in the preceding fall semesters and we plan to begin interviewing candidates in the following spring semester. For each position, a search committee will be established consisting of four faculty members and one graduate student. At least one of the search committee members will be female. The committee will initially filter applications, select a top tier list of candidates and the department as a whole will meet to discuss these candidates, or any others that faculty wish to discuss. The committee will continue its efforts until the best candidate is identified. Up to four candidates for initial interviews will be selected.

For on-site interviews, over the course of two days candidates will meet individually with all department faculty members and several outside the department to discuss their science and mutual interests. Candidates will meet with groups of undergraduate and graduate students, the Dean of the College, and any other interested parties. The candidate will present a public seminar on their research accomplishments. And each candidate will meet with the faculty as a whole to discuss the applicant's plans for initiating and sustaining their research program at NDSU. In our experience the critical elements that are important for successful recruiting of new faculty are research facilities, quality of graduate students, balanced teaching loads, supportive and collegial colleagues, salary and competitive startup funding.

The departments of Chemistry-Biochemistry and Coatings and Polymeric Materials have made significant effort to recruit a diverse faculty including females as well members from underrepresented groups. While both departments had been successful in recruiting female faculty in the past, three of these faculty have

left. *As both the department and the CSMS core group currently consist of nearly all male faculty, increasing gender diversity will be a high priority in these searches.*

Mentoring Plan

Once hired, the new faculty member will be mentored in the CSMS program and department/college. To integrate them into the program, each new faculty member will receive an orientation to the CSMS research program, its goals, and expected outcomes from the Center Director; be included in the regular team meetings; meet with each of the other team members to identify collaborations; and receive mentoring from senior faculty. In addition, after about six months of residency, each new faculty member will be expected to prepare a plan for their research including goals, milestones, and collaborations with other CSMS team members.

Every new faculty member is a large investment for the university. Therefore it is paramount to support and nurture the new faculty member to be successful. This is accomplished in many ways. Mentoring is critical for any new employee and our new faculty member will be assigned a senior colleague as a mentor. Monthly mentoring sessions throughout the academic year on topics such as grant writing, graduate student and postdoc recruitment, establishing collaborations, etc. are organized and available to new faculty. In addition to formal mentoring, senior faculty colleagues commonly aid each other in reviewing proposals and manuscripts as well as providing advice on issues of science and research. The NDSU-FORWARD program has played a major role in mentoring female faculty on the campus.

The Departments send junior faculty to grant writing workshops, such as "Gear-Up for Grants" and encourage them to take an active part in new faculty training seminars provided by the College. New faculty are not burdened with overly onerous administrative duties and committee involvement is kept minimal as they establish their independent research. All new faculty are provided a semester of release time from teaching in their first year to allow them to get up and running rapidly. Current teaching loads for research active faculty are one lecture course per semester. Senior faculty help make this possible by taking on extra teaching duties. In addition, the Departments provide additional resources for our new faculty to invite outside seminar speakers in their area to aid them in networking within their field. Funds are also provided in the startup package for junior faculty to travel to meet with funding agency officials and collaborators.

Resources Available

Additional resources are available to the new faculty members within the departments and across the NDSU campus. The Department of Chemistry and Biochemistry has outstanding research facilities for materials characterization (NMR, MS, X-ray), computation, Core Synthesis and Core Biology. These facilities are well staffed with Ph.D. level personnel for NMR, X-Ray, Synthesis and Biology. The Department of Coatings and Polymeric Materials has outstanding research facilities for polymer and characterization (GPC, DSC, DMTA, AFM (Atomic Force Microscopy), UV-Vis, FTIR, etc.), and affiliated units such as the CMRL (Combinatorial Materials Research Laboratory) and Electron Microscopy Center have additional equipment useful for polymer materials characterization. The Center for Computationally Assisted Science and Technology (CCAST) has computing infrastructure that can be used by the hires in Computational Polymer Science and Life Cycle Assessment.

Status as of 1/15/15

Department	Rank	Target Start	Research Area
CHEM*	Assistant Professor	Fall 2015	Synthetic Materials Chemistry
CPM**	Assistant Professor	Fall 2015	Bio-based Polymer Synthesis

*The organic chemist search is well underway; there are currently 42 applications and we expect to receive another 40+ when with the joint Chemical and Engineering News employment advertisement. The current timeline is that initial screening will start 2/15/15, with interviews in March-April and, hopefully, an offer approximately 5/1/15. [3/17/16 Update: Alexander Parent was hired and began his appointment with the NDSU Department of Chemistry and Biochemistry on August 16, 2015. Dr. Parent's Ph.D. is from Yale University. He was a NSF Graduate Fellow and a Postdoc at Kyushu University.]

**The search for the CPM assistant professor is also underway and applications are being submitted. We expect to more applications as a result of the joint Chemical and Engineering News employment advertisement. The current timeline is that initial screening will start 2/15/15, with interviews in March/April and, hopefully, an offer approximately 5/1/15. [3/17/16 Update: Mohi Quadir was hired and began his appointment with the NDSU Department of Coatings and Polymeric Materials on January 16, 2016. Dr. Quadir's Ph.D. is from Freie University-Berlin. He served as a Postdoc at MIT.]

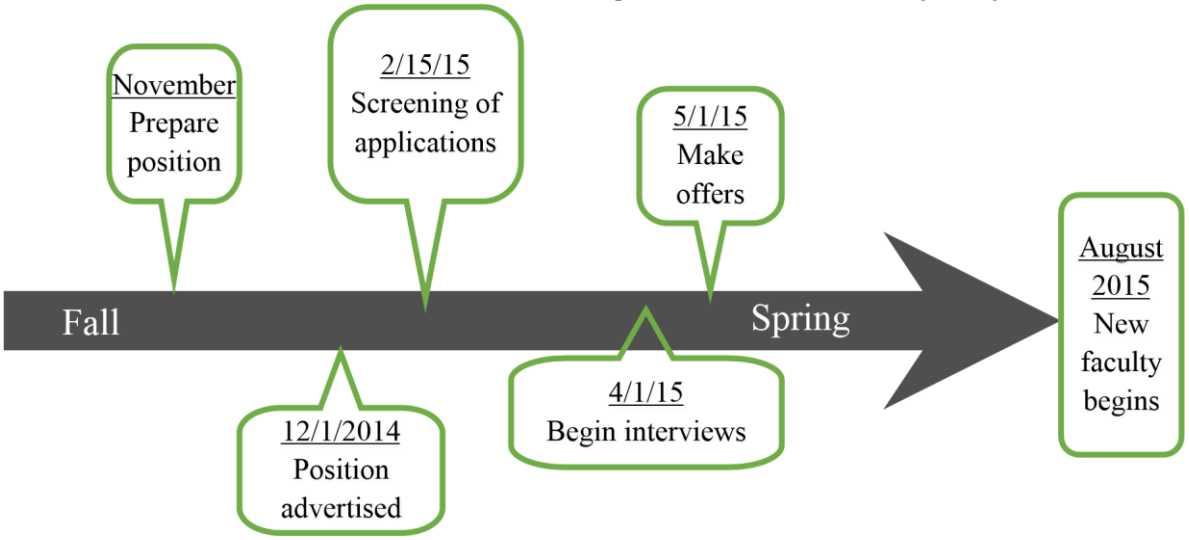
Risk Management Plan for New Faculty Hires

	Risk	Consequences	Impact	Likelihood	Mitigations
1.	Late start on first two hires.	Best candidates taken by other universities.	High	Moderate	Accelerate the process as much as possible; flip to a mid-year hire if needed.
2.	Inability to hire the right faculty member according to plan	Unable to meet metrics.	Moderate	Low	Identify and address potential weaknesses in recruiting approach. Ensure we have the right targets for recruiting. Redo search the following year.
3.	Inability to hire suitable Synthetic Materials Chemistry faculty member/or faculty leaves prior to end of grant.	Unable to meet metrics	Moderate	Low	Options to ensure metrics are met include: 1. Provide funding for additional graduate students and/or postdocs; 2. Use seed grant mechanism to provide funding for additional faculty to contribute to program.
4.	Inability to hire Biobased Polymer Synthesis (CPM) faculty member/or faculty leaves before end of grant.	Unable to meet metrics	Moderate	Low	Options to ensure metrics are met include: 1. Provide funding for additional graduate students and/or postdocs; 2. Use seed grant mechanism to provide funding for additional faculty to contribute to program.
5.	Inability to hire Computational Polymer Science faculty member/or faculty leaves before end of grant.	Unable to meet metrics	Moderate	Low	To ensure metrics are met the seed grant funding mechanism could be employed to provide funding for an existing faculty member to contribute to program. In addition, we could seek a suitable collaborator at another university.

6.	Inability to hire Life Cycle Assessment faculty member/or faculty leaves before end of grant.	Unable to meet metrics	Moderate	Moderate	To ensure metrics are met funding can be provided to continue the consulting activities of Professor Amy Landis, Arizona State University.

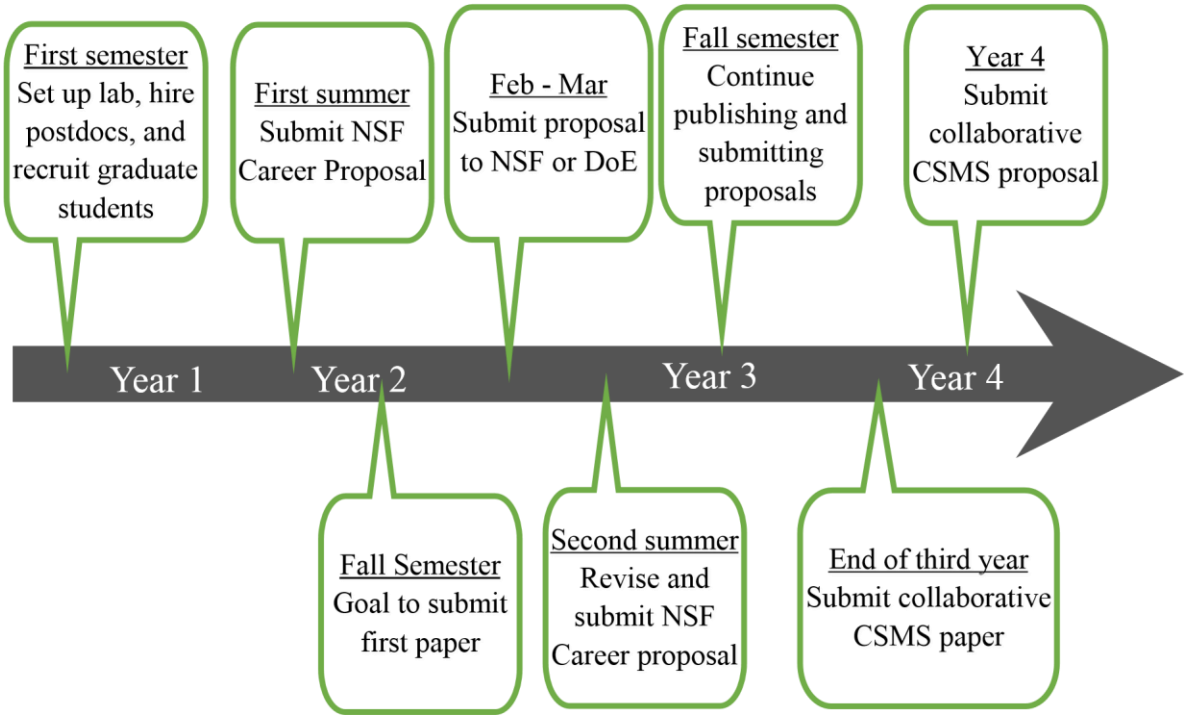
CSMS New Faculty Hiring Timeline

The timelines below are for the first two hires. Subsequent hires will be offset by one year.



Faculty Development Timeline

The timelines below represent the development protocols for all four hires.



APPENDIX 4.3: April 22, 2016 - NSF RSV recommendations

NATIONAL SCIENCE FOUNDATION
4201 Wilson Boulevard
Arlington, VA 22230

April 22, 2016

Dear Dr. Rusch,

Thank you for your participation and presentation at the recent Reverse Site Visit (RSV). The RSV is an important mechanism that NSF EPSCoR uses for project management and oversight, and for providing feedback and guidance to awardees. NSF EPSCoR commends you and your fellow team members for your professional approach to the RSV activity.

The attached report is based upon the RSV panel's review of written materials provided prior to the meeting (complete proposal, review panel summary, review analysis, original award letter, RII Track-1 strategic plan, and most recent annual report); the oral presentations made by the project team, visual aids supporting those presentations, and the subsequent question and answer periods with your team.

Based on the report, recommendations have been compiled by the managing Program Officer (PO) (see end of attached report). Please review the report and recommendations, share them with the appropriate individuals in your jurisdiction to develop responses and action plans that address the identified recommendations and required actions. Please contact your managing PO if you have any questions related to the panel's report, or if you need further clarification regarding the requested responses.

By May 20, 2016, please provide NSF EPSCoR with your written response to each of the recommendations. The response should detail the actions that will be taken and the timeline that you will use to address each recommendation. Responses should be emailed to Dr. Tim VanReken (tvanreke@nsf.gov) and Dr. Bob Coyne (rcoyne@nsf.gov). Please note that your next annual report for the RII Track-1 award (and subsequent reports, as appropriate) should include a section describing the progress that you have made toward addressing RSV recommendations.

Sincerely,
Dr. Bob Coyne
On behalf of NSF EPSCoR

Cc: Dr. Denise Barnes

Reverse Site Visit (RSV) Report

NSF EPSCoR Jurisdiction: North Dakota RII
Award Number: OIA-1355466
Principal Investigator: Kelly Rusch
RII Program Solicitation: NSF-13-549
Reverse Site Visit Date: March 17, 2016

Overview

The panel was favorably impressed with the overall progress of the North Dakota (ND) EPSCoR project. Careful consideration has been given to all aspects of the project and the institutions have made significant progress in the relatively short time since its inception. For most project goals the team appears to be on track or has a plan to address current issues. The new Center for Regional Climate Studies (CRCS) is already productive and Center for Sustainable Materials Science (CSMS) continues to build on its strengths.

The presentation was well organized, which suggests that the team is functioning as a unit. No serious problems requiring major reorganization of the management structure or center operations were noted.

Research Program

Center for Sustainable Materials Science (CSMS)

Summary of Strengths

The sustainable materials research adopts a cradle-to-cradle approach using biomass as feedstocks. The spectrum of materials includes various monomers and resins, monomers via catalytic preparation, photo-triggered monomers, vinyl ether-based soy polymers, lignin with enzymatic degradation, carbon dioxide utilization via chemical catalysis, polymer nanofibers, bio-based resins in composite fibers, and wheat grain- bioplastics. The center has built expertise over the years, and the activities in the first two years of this project are consistent with the past record. Productivity is evident, as indicated by recent journal papers, including two journal cover articles, and an *Angewandte Chemie* paper that attracted attention by the media. Most metrics involving North Dakota State University (NDSU) and the University of North Dakota (UND) are on schedule or ahead of schedule. There is a strong indication that the center will continue such productivity.

The positioned new hire on green catalytic synthesis of monomers further strengthens the sustainable organic chemistry and polymer chemistry work within the CSMS cluster. The other hire on bio-based polymers for biomaterials fills a missing piece in the center. The research expertise of these two assistant professors is a strong fit with the current team and therefore it seems likely that the hires will be successful. Two additional hires

are ongoing, in life cycle analysis (LCA) and computational polymer science. The plan to make hires in both of these areas is strongly commended by the panel. The interactive discussion during the RSV indicated that these are complementary needs that should lead to increased collaborations. The panel agrees that efforts to strengthen the intellectual infrastructure are on track.

There are indications that collaborations between NDSU and UND are underway and these interactions should be further enhanced. Although the research interaction with Tribal Colleges (TCs) and Primarily Undergraduate Institutions (PUIs) is still in its infancy, the mutual visits between the research universities and TCs/PUIs are a positive step. Visits by NDSU/UND faculty to TCs/PUIs during the academic year allow NDSU/UND faculty to become familiar with the research culture and environment of TC/PUIs. Additionally, students from TCs/PUIs can spend summers at NDSU or UND in order to become fully engaged in research activities. The translational research impacts from working with industry build on past interactions.

Summary of Weaknesses

Although the new hires overall are a benefit to institutional research capabilities, it is unclear how the LCA and computational hires will integrate with or bridge across the existing research directions and support the cradle-to-cradle approach. Their expertise could be used to proactively influence research decisions towards more sustainable chemical pathways or specific feedstock choices through simulation and environmental modeling. Thus it may have been better to bring the LCA and computational hires on board earlier. It is not clear if their role will be limited to evaluating the impact of individual synthesized polymers from each researcher or to guide research in a proactive manner. Additionally, the NDSU and UND participants have not actively engaged in developing collaborative proposals.

The panel felt that the research from TCs (involving Mongoh and LaVallie), focused on degradation pathways, is interesting and related to biopolymers but not truly integrated with the NDSU research focus. Current involvement with TCs/PUIs is relatively low, and no solution to improve the collaboration has been proposed. In addition to student involvement from TCs/PUIs, engagement of NDSU/UND and TCs/PUI faculty with appropriate two-way knowledge sharing should be considered. While the cluster investigators did not express concerns with the current level of staff support, the panel was concerned that this could limit progress and suggests that they consider support needs as the team grows with new hires.

The team described the importance of local agriculture and commodity crops but did not provide a clear description of biomass type and origin used as feedstock. The use of locally-grown crops would improve the sustainability of the research project and encourage local startups.

Center for Regional Climate Studies

Summary of Strengths

The CRCS effort is only in its second year but already has published results on a variety of research topics. It is clear that the participants are very active in numerous efforts such as agricultural impacts, data gathering, deployment of new instrumentation and sensors, diesel particulates, downscaling of climate model results, and understanding climate change impacts in the Devil's Lake region, among others. The investigators also have been active in submitting proposals for funding although they have not yet engaged in interinstitutional collaborative proposals.

CRCS is using sound methodology to address their research topics. The combination of experimental and modeling approaches is effective. The climate downscaling efforts use both dynamical and statistical downscaling, with the latter including a combination of relatively simple methods such as bias correction along with more detailed methods. Research on climate and crop yields takes advantage of both remote sensing and crop models, though this process has been slowed because the Decision Support System for Agrotechnology Transfer (DSSAT) modeling has been delayed.

The development of an integrated assessment model, combining climate, hydrology and economic models, is a strong positive outcome from the project. It is clear that multiple fields are converging on the recognition that this approach is essential not only for evaluating climate impacts but also for evaluating climate change itself. The investigators are commended for taking this approach and are strongly encouraged to continue its development, using it as a framework for linking expertise and research activities at the participating institutions. This cutting-edge capability would help the state become more competitive for large multi-investigator and multi-institution funding opportunities.

The investigators have shown themselves to be nimble and adaptable when opportunities arise. An example is their rapid response study of the weather and climate effects from large wildfires. Studies such as this also have the potential to capture public interest and as such could serve as gateways to STEM education (see later comments). Research on agricultural autonomous adaptation has combined farmer interviews with crop modeling and policy considerations. The investigators are commended for recognizing that farmers are more responsive in individual rather than group settings, and for revising their methodology accordingly.

The CRCS research thrust potentially is a strong draw for engaging TC participation, as it may appeal to cultural interests. There appears to be good TC participation arising from genuine interest by investigators at UND and NDSU in engaging TCs.

Summary of Weaknesses

The goals of the project are very appropriate, in particular for the region, but it was hard to follow how all of the various activities within CRCS relate to the overall goals and objectives surrounding regional climate studies. As discussed during the panel meeting, it appears that many of the seemingly unrelated projects to date are a result of a positive effort to fully engage TCs/PUIs. Although this is commendable, the panel suggests that the team clarify how this work relates to the broader research effort and

identify the linkages to regional climate work more clearly. For example, research related to bats and their role as pollinators has surfaced as a very sensitive indicator of climate change in the region, thus potentially impacting agricultural management decisions, but this link was not clearly articulated. In summary, the panel suggests that the somewhat disconnected research efforts be recognized as 1) contributing to the broad research goal of understanding regional climate impacts on agriculture and 2) responding to the research interests of the TCs/PUIs.

Related to downscaling of climate models and linking them to hydrological models, the panel noticed that opportunities were missed to interact with the broader research community. Such interactions would enable the research cluster to build relationships with external model users and developers, as well as help to place this work in a broader context within the US. There are several community-based efforts relevant to project activities, such as the Coordinated Regional Climate Downscaling Experiment (CORDEX). Participation in these efforts would not only provide opportunities for data sharing but also help to form collaborations with other institutions leading to joint publications and proposals. For example, downscaling two general circulation models (GCMs) gives only a very preliminary indication of model-based uncertainty (as an aside, it was not clear what criteria were used in selecting the GCMs to downscale). Engagement with CORDEX and other community efforts would broaden the range of model output available and help to guide assessment of uncertainty in climate projections relevant to the project. The investigators should also consider applying for computing resources from the National Center for Atmospheric Research (NCAR). In addition to providing computing power, NCAR staff can assist with optimizing models for better performance.

Another weakness is the lack of interinstitutional collaborative proposals submitted by the CRCS cluster. This is an area that demands attention, in particular as the project moves into the remaining three years of the grant and the investigators look towards sustainability of this work.

Project Elements

Diversity

The panel was impressed with the strong commitment to diversity shown by the entire team. It was evident that a good deal of thought was put into working with the Native American population of North Dakota with an ethical approach based on mutual benefit and two-way communication. The tribal liaison they have hired has two decades of experience working at a tribal college and will be a strong leader for this effort. In addition, the project leadership are all engaged in this effort—everyone who spoke at the RSV was able to talk confidently about some aspect of the collaborations with tribal colleges. Many of the faculty and graduate students are involved in the Native programs (such as mentoring at the summer camp or planning lessons for the Sunday Academy). Research partnerships with the TCs and PUIs were initiated with active listening sessions before research projects were determined. Another example of

ethical partnership is the Institutional Review Board (IRB) and Reservation Review Board (RRB) processes that have already been set up through four of the TCs.

There is funding for summer Research Experience for Undergraduate (REU) students through the award, and leveraged funding with other REUs at NDSU and UND. The PIs have worked to include nontraditional students by funding students to work at their home institution.

The Native American programs have been slow to get off the ground. Efforts to launch the Native American Success in Science and Engineering (NASSE) program have been hampered by inability to complete hiring of mentors. The K-12 program, which is up and running, has thus far attracted lukewarm attendance. The original REU cohort of 5 that will begin this summer includes only one TC student. Efforts to attract Native American candidates to the expanded Nurturing American Tribal Undergraduate Research and Education (NATURE+) graduate program have not yet succeeded. These results only underline the difficulty of the undertaking—it will take sustained and patient effort to create the sort of state-wide systemic change that will lead to true progress in increasing numbers of Native Americans in STEM programs in ND. The EMPOWERED-ND (EMerging PrOgrams for WorkforcE Development, OutReach, Education and Diversity - North Dakota) committee will be instrumental in overcoming these challenges. Every effort should be made to review current literature on best practices for recruiting and retaining Native American students in STEM.

The panel has suggestions for the team to consider in strengthening their diversity effort. The project team should take leadership in building knowledge on issues such as broadening participation of Native Americans in STEM, and creating undergraduate programs to serve nontraditional students. The co-leads seem well qualified to lead this effort. The research of Dr. Eric Jolly (a Cherokee native) stresses the importance of going beyond initial engagement in STEM and is recommended reading (see http://www.campbell-kibler.com/trilogy.pdf). Many of the project's Native American programs seem focused solely on engaging students with STEM and need to go further toward improving students' preparation and capacity. The EMPOWERED-ND committee is an excellent forum for developing collaborations that can test strategies for moving beyond engagement towards full participation in STEM. Since the REU will be a distributed-REU the panel recommends the excellent papers coming out of the NCAR Significant Opportunities in Atmospheric Research and Science (SOARS) program (*e.g.*, Haacker, 2015, Nature Geoscience). Further advice on models for undergraduate research can be found on the Council on Undergraduate Research web site (http://www.cur.org). A good starting point for information on climate change adaptation on Native reservations is found at:
https://www.iltf.org/sites/default/files/wmitchell_law-review_2015_03_3.-Ford_Giles.pdf

Workforce Development
The workforce development plan was strengthened when the Future Farmers of America (FFA) and 4H partnerships were replaced by a program to work with rural schools. The team already has made substantial progress on this transition. The

project team made a strong case for providing teaching materials for schools that are challenged by lack of adequate teaching tools. It is recommended that close attention be paid to state and national standards as the team moves forward with developing these teaching tools. Perhaps workshops for rural teachers could support implementation of these materials.

Communication

The panel suggests increasing communication efforts to raise the program's visibility in media outlets as well as general recognition of the research. One minor weakness is the missed opportunity for additional media coverage. The panel commends the excellent response to the media attention on the article published in the journal *Angewandte Chemie*, but also believes that the rapid response journal article published about the Canadian wildfire smoke event could have had similar impact in the media. There was no clear description of how the communication/media efforts are incorporated into the EPSCoR management team. The panel suggests increasing communication efforts with the general population. This could include specifically promoting center activities to the farm population and connecting with the state climatologist. The REU website should be improved, and the team should look into using social media for improving recruiting and dissemination.

Evaluation and Assessment

The Evaluation and Assessment Plan was seen as a strength of the program. The metrics are, for the most part, clear and concise. The evaluation work that has been carried out to date was focused and to the point. The reports provided by the external evaluator and the external advisory board (EAB) gave good feedback and provided useful information for the panel.

No mention was made of how the team plans to address areas where the metrics are low, and there weren't a lot of details on why the project is not meeting some of the metrics. The panel had no objections to metrics that were being changed.

Cyberinfrastructure

The report on cyberinfrastructure was presented as part of the strategic foci and as an enabling technology. There was no formal presentation on the state of the development of cyberinfrastructure. The panel gleaned from the question and answer session that the dominant need for cyberinfrastructure is for the CRCS project. The panel felt that the cyberinfrastructure needs are being met and that there are plans for confronting future challenges. The Center taps into the Extreme Science and Engineering Discovery Environment (XSEDE) program for advanced computing. The projects make use of a state-wide video conferencing system for meetings and for the delivery of classroom materials. The CRCS should explore collaboration with NCAR (as noted above in the comments on CRCS).

Sustainability

The sustainability plan appears to be well developed. The panel views the diversity aspect of the project to be on the path to sustainability enabled by a well-considered

approach to fostering partnerships. CSMS should look toward linkages that would sustain their work beyond the end of the present project, for example by formally developing research consortia with industry, perhaps by taking advantage of NSF programs such as I-CORPS, I/UCRC, STTR or SBIR. The CRCS is beginning to consider sustainability primarily through future collaborative proposals. This was commended by the panel and should be vigorously pursued.

External Engagement

There are several aspects of the project that involve external engagement. The project is forming partnerships with stakeholders and collaborations with institutions that would add value to the research. The CSMS has developed partnerships with industrial ventures with a view to seeking translational opportunities for the research. It was not entirely clear how the CSMS industrial partnerships will lead to technology transfer. The CRCS has developed partnerships with various parts of the agriculture sector that would benefit from the research outcomes. Such partnerships are considered to be appropriate and to benefit the project in that internship opportunities are likely through several of the industrial partners. The external engagement serves the project well. The benefits that would accrue through industrial partners are clear and the project is in a position to take advantage of such engagement.

The nature of the collaborations with the national labs was not always clear, although in some cases it seems the collaboration is targeted and results from a need within the project. More strategic thought should be given to the development of collaborations with national labs. The project should better delineate how the collaborations with national labs and agencies relate to the thematic areas of the project.

Management

The project shows evidence of an interactive and unified management scheme. Senior management appears to have a strong grasp of and engagement with the project components. The project has longevity with a core team that is competent and active. Thus far, the leadership team has been very productive and the external signs are that the relationships among the leaders are synergistic. The panel observed that the collaboration between NDSU and UND is not as strong as desired, and thought that the management team should examine ways to improve this potentially strong element of the project.

Jurisdiction-Specific Award Conditions

The CRCS has modified their original research plan from the strategic plan as it relates to their interactions with farmers. The panel believes the change from focus groups to qualitative interviews will provide better insight on autonomous adaptation.

The hiring plan for CSMS was addressed in the strategic planning. Two new faculty members focusing on polymer synthesis and catalysis joined last year and the last two hires should be completed shortly for an anticipated August 2016 starts.

Summary

The panel would like to reemphasize that the project team has made impressive progress. The team should give consideration to the following areas. 1) The project has the potential to inspire the citizens of ND with the research that is being done. The leadership should create a strategy for improving external communication. 2) Inter- institutional collaborative proposals are essential steps towards the sustainability of the centers. The leadership should develop a strategy for motivating center researchers to deliver these proposals. 3) The research clusters would benefit by connections to the broader research communities (within and outside ND) that share tools, techniques, facilities, and data. 4) The project should consider developing an overarching diversity strategic plan that will synthesize activities, address barriers, and lead towards systemic change. This work should be accomplished collaboratively, probably best through the EMPOWERED-ND committee.

Recommendations

1. The panel was impressed with the impactful research being done by the two centers, and was pleased to see that some of the work was receiving attention beyond the traditional bounds of academia. However, the panel felt that broader impacts could be achieved *via* an improved, systematic, proactive external communications strategy. Develop a plan for improving the project's external communications, including traditional media engagement, social media, and web presence. This plan may involve closer coordination between the project and the participating institutions' existing resources, or it may involve more direct involvement of the project team and/or state EPSCoR office personnel.

2. The panel identified several areas where the project team would benefit substantially from strong ties with external collaborators and other partners. For the CRCS, this includes engagement with CORDEX to strengthen the climate modeling activities. For the CSMS, the panel suggested that the project would benefit from more clearly defined objectives for interactions with industry. Additional potential partners were identified to strengthen ND EPSCoR's long-term strategies for broadening participation (*e.g.,* SOARS, CUR, and national networks for Native Americans in STEM). Building from these suggestions, specify a set of specific objectives for improving the project's external collaborations and partnerships.

3. Although sustainable cross-institutional collaborations are critical to the long-term success of the two centers, collaborative funding proposals have been slow to develop. While this may in part be just the natural progression of the centers as they become established, the panel felt that more could be done to catalyze cross- institutional research ties in a tangible way. Develop a plan to further facilitate cross- institutional ties for each of the two centers, with a specific focus on sustainable collaborations beyond the current project's scope. Cross-institutional links among the current project participants are critical, but ideally the plans will include broader collaborative partnerships as well.

4. The panel noted that in its efforts to establish research collaborations with TCs and PUIs, the project team has initiated some projects whose connections to the Centers' overall scopes are somewhat ill-defined. This approach is justifiable, but raises some concern about Center cohesion and the sustainability of the collaborations. The project is encouraged to consider how they might adjust their Centers' vision and goals to provide a more inclusive environment for projects like those being established at the TCs and PUIs, and to provide a clearer basis for evaluating whether similar future efforts are consistent with the Centers' goals.

APPENDIX 4.4: May 20, 2016 - ND EPSCoR response to NSF RSV recommendations

ND EPSCoR
Experimental Program to Stimulate Competitive Research

May 20, 2016

Drs. Tim VanReken and Bob Coyne,

Attached is ND EPSCoR's response to the recommendations made by the NSF EPSCoR RSV panel following our March 17, 2016 visit with them.

ND EPSCoR is appreciative of the time the NSF EPSCoR RSV panel spent in reviewing ND EPSCoR's materials and agrees with their thoughtful recommendations. Please thank them for us.

ND EPSCoR has already taken and will continue to take steps to address each of the four recommendations made by the panel:

1. Develop a plan for improving the project's external communications, including traditional media engagement, social media, and web presence;
2. Specify a set of specific objectives for improving the project's external collaborations and partnerships;
3. Develop a plan to further facilitate cross-institutional ties for each of the two centers, with a specific focus on sustainable collaborations beyond the project's scope; and
4. Adjust the CSMS' vision and goals to provide a more inclusive environment for projects like those being established at the TCs and PUIs to provide a clearer basis for evaluating whether similar future efforts are consistent with CSMS' and CRCS' goals.

Additionally, although not addressed in the above RSV panels' recommendations, ND EPSCoR appreciates the concerns of the RSV in the following areas:

- CSMS timeline related to the hiring of LCA and computational faculty - The LCA and computational hires will be able to quickly become involved in the project once they come on board. The LCA hire is expected to initially provide assessment of the sustainability of current work and then eventually be able to provide input to our proposed methods to help us focus on the approaches with the highest degree of sustainability. Similarly, we expect the computational hire to initially work with the experimentalists to provide deeper understanding of the properties of the materials as a function of structure that they are currently making and then become involved in using this understanding to help predict properties as a function of composition in order to proactively direct the research effort. The timeline was impacted because we did not have the resources to conduct four searches simultaneously and so prioritized the positions to conduct two searches in each of the first two years. We selected to recruit the experimental scientists first since it was felt that they had a greater "induction period" in getting their laboratories set up, while we believed that the LCA and computational scientists could get their work off the ground much more quickly.
- CSMS collaborative proposals – Although the Center reported on several collaborative proposals between CSMS team members during the RSV, this effort will accelerated as we complete year 2 and move into year 3. Many active discussions are being held and since the RSV, a large collaborative proposal between four CSMS members was submitted for funding. Additionally, an INFEWS proposal with several CSMS team members and Sitting Bull College (Mafany Mongoh, co-PI) was submitted in March 2016. In most cases, it is important to demonstrate that the team

members have ongoing collaborations and so our current collaborative research efforts and joint publications are important in order to set the stage for submission of competitive collaborative proposals.

- CRCS' limited interaction with broader climate studies community – Although not reported at the RSV, CRCS researchers are active within the WRF community and there are now plans to reach out to the North America CORDEX dynamical downscaling contacts about future plans. Regarding CRCS computing time, we currently use annual NSF XCEDE computing proposals/time to perform our simulations. Our current computing time will expire on June 30th and we will be submitting a follow-on proposal for the upcoming year. If inadequate time is given, then NCAR facilities are certainly possible, however, XCEDE is preferred due to CRCS researchers' familiarity with the system.

Finally, ND EPSCoR is appreciative of the time spent by each of you and other NSF EPSCoR personnel. Please let me know if you have any questions regarding our attached response to the panel's recommendations.

Sincerely,

Dr. Kelly A. Rusch
ND EPSCoR PI and Project Director

Cc: Dr. Denise Barnes, Section Head for EPSCoR, NSF
Dr. Mark R. Hoffmann, Co-PI and ND EPSCoR Associate Project Director
Dr. Jean Ostrom-Blonigen, CPA, Co-PI and ND EPSCoR Project Administrator
Dr. Grant McGimpsey, ND EPSCoR State Steering Committee Chair
Dr. Scott M. Hanson, ND EPSCoR Tribal Colleges Liaison

The North Dakota EPSCoR team appreciates the opportunity to provide additional information on the current and future direction and activities of its NSF Track-1 programs. Updates and information pertaining to the four recommendations provided by the Reverse Site Visit Team are outlined below. For some of the recommendations, expanded planning was already underway at the time of the Reverse Site Visit on March 17th.

NSF PANEL RECOMMENDATION #1: Develop a plan for improving the project's external communications, including traditional media engagement, social media, and web presence

There are numerous activities currently underway and/or planned that are intended to increase access to NSF EPSCoR information, communicate important news and disseminate results to the public. These include:

- In response to the January audit [the audit was completed by Jean Ostrom-Blonigen, Mark Hoffmann, Scott Hanson, ND EPSCoR Leads/Co-Leads, ND EPSCoR staff and Rose Shaw, external evaluator] of the two research centers' websites:
  - CSMS has completed all the recommended revisions to its website (http://csms-ndsu.org/). The CSMS website is monitored on a weekly basis for outdated information and the addition of new information to ensure the site remains relevant and that older information is archived. Additionally, CSMS utilizes both Facebook and twitter as communication avenues, with access via the website.
  - CRCS has [as of May 19th] not completed the recommended revisions from the January audit (http://crcs.und.edu/). Until these revision have been complete, the Year 3 funding of CRCS Co-Lead Frank Bowman will be delayed. CRCS currently does not directly use Facebook/twitter as additional communication avenues. However, CRCS uses the Citizen Science Grid (run from the UND Computer Science Department) to do climate tweets and inform the greater public and community to communicate valuable climate information to the general public (http://csgrid.org/csg/climate/).

- The overall ND EPSCoR website has been completely revamped and went live on April 26, 2015 (https://www.ndepscor.ndus.edu). The changes include a new web address to reflect that ND EPSCoR is an entity of the North Dakota University System, new branding/logo, movement of the site to a NDSU hosted web platform [typo 3] and a web portal to ERcore for ND EPSCoR participants. The new website is much more content rich. Additional content will be continually added to ensure important news is conveyed to the public and interested parties. While the two research cluster have independent websites, the ND EPSCoR leadership will work with the Tribal College Liaison to create a webpage under the overall ND EPSCoR website devoted to Tribal College and Primarily Undergraduate Institution activities, results and communications. The target deadline for uploading content to this page is August 15, 2016.

- Prior to June 15, using methodology learned at those NSF workshops, ND EPSCoR leadership and the Partnerships, Collaborations and Communication team will conduct a SWOT analysis of external communications, including traditional media engagement, social media, and web presence. Prior to July 1, led by Co-Leads, Mukund Sibi (NDSU) and Frank Bowman (UND), the Partnerships, Collaborations and Communication team will use the SWOT analysis to create an action plan for improving the project's external communications, including traditional media engagement, social media, and web presence during year three to ND EPSCoR Leadership. As

part of that action plan, the Co-Leads will recommend revisions to CSMS/CRCS budgets to accomplish their plan.

- As background, ND EPSCoR sent a five-member team to the recent NSF (#EPS-1521666) Innovation, Entrepreneurship, and Translational Research workshop series (Workshop 1: October 5-6, 2015 in Nashville, TN and Workshop 2: February 1-2, 2016 in Las Vegas, NV).
    - ND EPSCoR's team consisted of Jean Ostrom-Blonigen, ND EPSCoR Project Administrator; Tara Kopplin, Licensing Associate, Intellectual Property and Economic Development, UND; Michael Moore, Associate Vice President, Intellectual Property and Economic Development, UND; Jolynne Tschetter, Executive Director, Corporate and Foundation Research Relations, NDSU; and Chad Ulven, Associate Professor, Mechanical Engineering and Track-1 CSMS researcher and Diversity Co-Lead, NDSU.
    - During Part 1 of the workshop series, ND's team conducted a SWOT analysis of the ND landscape related to innovation, entrepreneurship and translational research. Upon returning to ND, the team worked with Kelly Rusch, ND EPSCoR Project Director and Mark Hoffmann, ND EPSCoR Associate Project Director to prioritize three strengths, three weaknesses, three opportunities and three threats with this landscape; to develop an objective for applying the SWOT to improving the Track-1 external collaborations and partnerships (see below); and to devise an Action Plan.
    - During Part 2 of the workshop series, ND met with other jurisdictions and learned about their Action Plan(s) and presented ND EPSCoR's Action Plan. A follow-up meeting, which had been scheduled for May 10, 2016, is in the process of being rescheduled to include the Partnerships, Collaborations and Communication Co-Leads: Mukund Sibi, Distinguished Professor, Chemistry and Biochemistry, NDSU and Frank Bowman, Associate Professor, Chemical Engineering, UND.

NSF PANEL RECOMMENDATION #2: Specify a set of specific objectives for improving the project's external collaborations and partnerships

Once again, there are numerous activities currently underway and/or planned that are intended to improve the project's external collaborations and partnerships. Similar to the steps outlined in Recommendation #1 above, these include:

- ND EPSCoR sent a five-member team to the recent NSF (#EPS-1521666) Innovation, Entrepreneurship, and Translational Research workshop series (Workshop 1: October 5-6, 2015 in Nashville, TN and Workshop 2: February 1-2, 2016 in Las Vegas, NV).
    - ND EPSCoR's team consisted of Jean Ostrom-Blonigen, ND EPSCoR Project Administrator; Tara Kopplin, Licensing Associate, Intellectual Property and Economic Development, UND; Michael Moore, Associate Vice President, Intellectual Property and Economic Development, UND; Jolynne Tschetter, Executive Director, Corporate and Foundation Research Relations, NDSU; and Chad Ulven, Associate Professor, Mechanical Engineering and Track-1 CSMS researcher and Diversity Co-Lead, NDSU.

- During Part 1 of the workshop series, ND's team conducted a SWOT analysis of the ND landscape related to innovation, entrepreneurship and translational research. Upon returning to ND, the team worked with Kelly Rusch, ND EPSCoR Project Director and Mark Hoffmann, ND EPSCoR Associate Project Director to prioritize three strengths, three weaknesses, three opportunities and three threats with this landscape; to develop an objective for applying the SWOT to improving the Track-1 external collaborations and partnerships; and to devise an Action Plan.
    - Additional personnel included in the January 12, 15 and January 22, 2016 meetings, who reviewed ND EPSCoR's Action Plan were: Frank Bowman, CRCS and Partnerships, Collaborations and Communications Co-Lead, UND; Mark Hoffmann, ND EPSCoR Associate Project Director; Henry Nowak, Technology Manager, Technology Transfer Office, NDSU; Grant McGimpsey, ND EPSCoR Steering Committee Chair, UND; Kelly Rusch, ND EPSCoR Project Director, NDSU; Mukund Sibi, CSMS and Partnerships, Collaborations and Communications Co-Lead, NDSU; and Dale Zetocha, Director, Technology Transfer Office, NDSU.
- During Part 2 of the workshop series, ND met with other jurisdictions and learned about their Action Plan(s) and presented ND EPSCoR's Action Plan. A follow-up meeting, which had been scheduled for May 10, 2016, is in the process of being rescheduled to include the Partnerships, Collaborations and Communication Co-Leads: Mukund Sibi, Distinguished Professor, Chemistry and Biochemistry, NDSU and Frank Bowman, Associate Professor, Chemical Engineering, UND.

Although listed in the notes to the RSV slide deck (slide #142), we neglected to mention our preliminary work in this area to the NSF panel during our March 17, 2016 RSV (draft versions of our efforts to date are attached). Prior to June 15, using methodology learned those NSF workshops series, ND EPSCoR leadership and the Partnerships, Collaborations and Communication team will conduct a SWOT analysis of ND EPSCoR Track-1 external collaborations and partnerships. Prior to July 1, led by Co-Leads, Mukund Sibi (NDSU) and Frank Bowman (UND), the Partnerships, Collaborations and Communication team, will use the SWOT analysis to create an action plan for improving the project's external collaborations and partnerships during Y3 to ND EPSCoR Leadership. As part of that action plan, the Co-Leads will recommend revisions to CSMS/CRCS budgets to accomplish their plan. Additionally, planned for Y4/Y5, are translational seed awards designed to move the centers' research into the commercial arena.

NSF PANEL RECOMMENDATION #3: Develop a plan to further facilitate cross-institutional ties for each of the two centers, with a specific focus on sustainable collaborations beyond the project's scope

ND EPSCoR will facilitate cross-institutional ties for each of the two centers, with a specific focus on sustainable collaborations beyond the project's scope. Specifically:

- As outlined in ND EPSCoR's original NSF proposal, emerging seed awards will be awarded in Year 3/Year 4 that facilitate these types of cross-institutional collaborations. The RFPs for these awards [on both the NDSU and UND campuses] will be carefully written to promote cross-institutional ties. Priority will be given to proposals that include faculty from both campuses [co-funded by both campuses]. Prior to August 1, working with ND EPSCoR Leadership, Dean Webster (CSMS Lead) and Jianglong Zhang (CRCS Lead) will develop specifics, including a timeline, for issuing these requests for proposals.

- The EPSCoR leadership team will coordinate and implement [beginning with Year 3], quarterly face-to-face (if winter conditions do not allow for travel, that quarterly meeting may be held via ND's interactive video network (IVN)), required workshop meetings of the CSMS and CRCS teams [location will rotate amongst institutions] to provide a venue for each team to present ideas, overlapping themes that could lead to joint publications and potential funding sources for new, collaborative proposals. These face-to-face meetings will complement the on-going monthly meetings that the research teams have via video conferencing. While collaboration cannot be forced, this required and expected outcome of this workshop series is for the researchers within each cluster to think through collectively how each independent research project fits into the larger picture.

- On April 10, 2016 [in process at the time of the Reverse Site Visit], two additional researchers were added to the two research clusters; one at UND and one at NDSU. Each researcher was carefully selected and discussed by the EPSCoR leadership and the CSMS and CRCS Leads/Co-Leads to ensure that they fit into the existing research framework of each cluster. The research cluster budgets have been adjusted accordingly to provide the resources for these two researchers:
    - The addition of Alena Kubatova, Professor, Chemistry, UND, to CSMS will help build additional cross-institutional ties. Dr. Kubatova has existing relationships with the CSMS researchers at NDSU and TMCC; specifically:
        - Dr. Kubatova is the ND lead for the joint ND/SD DakotaBioCon, EPSCoR Track 2 project.
        - Dr. Kubatova has been working with Dr. Audrey LaVallie, TMCC, to set up a GC-MS system to analyze plant extracts. This interaction will fit nicely with CSMS as Dr. LaVallie works to study plant extracts and identify those that might be suitable as raw materials for the synthesis of bio-based polymers.
    - Dr. Kubatova leads a NSF REU with the theme of" Interdisciplinary Renewable and Environmental Chemistry" which fits well with the overall themes of CSMS and will provide synergistic interactions with our other undergraduate research efforts.The addition of Erin Gillam, Associate Professor, Biological Sciences, NDSU, to the CRCS will help build cross-institutional ties. Dr. Gillam has existing relationships with the CRCS researchers at DSU and UTTC; specifically:
        - Dr. Paul Barnhart (DSU) did his Ph.D. work under Dr. Gillam and maintains active collaborations with her lab. As a result of these collaborations, her research involving the b*ehavioral ecology of mammals in the Great Plains,* with a focus on bats, will augment the work already being done by Track-1 researchers at those institutions in the following ways: Dr. Gillam's research on the ecology of the federally threatened northern long-eared bat, *Myotis septentrionalis*, will supplement ongoing work by Dr. Barnhart and others focused on the impacts of land use changes soil characteristics, microbiota, insect diversity and bat diversity.
        - Ms. Mandy Guinn (UTTC) has been collaborating with Dr. Gillam for four years, with the two researchers having jointly received two USDA NIFA grants for running a REU program for tribal college students. Dr. Gillam's work ties in nicely with research being conducted by Ms. Guinn on how bat diet is impacted by the extensive presence of agricultural fields in the Great Plains; specifically,

we can couple our sampling efforts to potentially expand Ms. Guinn's sampling area and to look at this federally threatened species.

- Finally, Dr. Gillam will also work with other Track-1 researchers, specifically those in the UND Department of Atmospheric Science, to bring field data into a geospatial modeling environment to understand how predicted impacts of global climate change will alter the availability of preferred *M. septentrionalis* habitat in the Great Plains.

- Partial funding from Year 3 will be conditionally set aside and released as cross-institutional metrics are met.

NSF PANEL RECOMMENDATION #4: Adjust the CSMS' vision and goals to provide a more inclusive environment for projects like those being established at the TCs and PUIs to provide a clearer basis for evaluating whether similar future efforts are consistent with CSMS' and CRCS' goals.

Following the Reverse Site Visit, both the CSMS and CRCS revised its objective to better incorporate the TC/PUI researchers into the clusters [this is reflected in the revised Strategic Plan that was submitted to NSF on April 4, 2106]. In summary, the revised objectives include:

CSMS incorporated:

- Mikhail Bobylev's (MiSU) work related to synthesis of novel polymers from biomass using a method he recently patented to:
  - Objective 1.3: Engineer high performance polymers and composites from bio-based raw materials. Benchmark against current appropriate petrochemical counterparts - develop novel polymers from biomass.

- Khwaja Hossain's (MaSU) work related to the study of bio-based composite synthesis using wheat bran to:
  - Objective 1.7: Study performance properties of composites made using bio-based fillers and fibers. Benchmark against current appropriate petrochemical counterparts - study performance properties of composites made using bio-based fillers and fibers.

- Mafany Mongoh's (SBC) work related to sustainable biodegradation of polymers - impact of microorganisms in the environment to:
  - Objective 1.9: Design materials with programmed degradation capability so that raw materials and fillers can be recycled - develop methods for sustainable biodegradation of polymers.

- Audrey LaVallie's (TMCC) work related to the analytical aspects of biomass chemical components to:
  - Objective 1.9: Design materials with programmed degradation capability so that raw materials and fillers can be recycled - develop methods for sustainable degradation of lignin.

CRCS incorporated:

- Kerry Hartman's (NHSC) work related to the impact of climate change on juneberry pollination and yield to:
    - Objective 1.1: Analyze regional climate variations and data uncertainty – conduct observational based regional climate studies.
    - Objective 1.4: Determine crop productivity response to climate change - - apply large data statistical methods to identify yield response of major crops in the NGP.

- Andre DeLorme and Casey William's (VCSU) work related to studying the impact of climate variations on fish species and other aquatic organisms (e.g. Mussels) in ND to:
    - Objective 1.3: Analyze regional climate variations and data uncertainty - collect precipitation and hydrologic data.
    - Objective 1.6: Explore feedback to environment of land use changes - evaluate impact of land use change on quality of water resources.

- Brent Voels's (CCCC) work related to the Impact of oil spill impacts on ag-economy and Mandy Guinn's (UTTC) work related to bat impact on ag-economy to:
    - Objective 1.5: Predict agricultural autonomous adaptation in response to changing climate and crop productivity - identify the psychological, social, and historical factors that contribute to decision making by ND farmers and ranchers.

- Erik Brevik, Joshua Steffan and Paul Barnhart's (DSU) and work related to the impacts of climate on soil chemistry and bats and their feedback to the environment to:
    - Objective 1.6: Explore feedback to environment of land use changes - quantify impact of land use change on ecosystem services.

Additionally, as noted in the response to Recommendation #3, Drs. Kubatova and Gillam have been added to the research clusters.

- The addition of Alena Kubatova, Professor, Chemistry, UND, to CSMS will help build additional cross-institutional ties. Dr. Kubatova has existing relationships with the CSMS researchers at NDSU and TMCC; specifically:
    - Dr. Kubatova is the ND lead for the joint ND/SD DakotaBioCon, EPSCoR Track 2 project.
    - Dr. Kubatova has been working with Dr. Audrey LaVallie, TMCC, to set up a GC-MS system to analyze plant extracts. This interaction will fit nicely with CSMS as Dr. LaVallie works to study plant extracts and identify those that might be suitable as raw materials for the synthesis of bio-based polymers.
    - Dr. Kubatova leads a NSF REU with the theme of" Interdisciplinary Renewable and Environmental Chemistry" which fits well with the overall themes of CSMS and will provide synergistic interactions with our other undergraduate research efforts.CSMS Leads, Dean Webster and Mukund Sibi, are working to revise the CSMS' strategic plan objectives to show the addition of Dr. Kubatova's research and the integration of research being conducted at the TCs and PUIs. This will be finished by no later than June 30th.

- The addition of Erin Gillam, Associate Professor, Biological Sciences, NDSU, to the CRCS will help build cross-institutional ties. Dr. Gillam has existing relationships with the CRCS researchers at DSU and UTTC; specifically:
    - Dr. Paul Barnhart (DSU) did his Ph.D. work under Dr. Gillam and maintains active collaborations with her lab. As a result of these collaborations, her research involving the b*ehavioral ecology of mammals in the Great Plains,* with a focus on bats, will augment the work already being done by Track-1 researchers at those institutions in the following ways: Dr. Gillam's research on the ecology of the federally threatened northern long-eared bat, *Myotis septentrionalis*, will supplement ongoing work by Dr. Barnhart and others focused on the impacts of land use changes soil characteristics, microbiota, insect diversity and bat diversity.
    - Ms. Mandy Guinn (UTTC) has been collaborating with Dr. Gillam for four years, with the two researchers having jointly received two USDA NIFA grants for running a REU program for tribal college students. Dr. Gillam's work ties in nicely with research being conducted by Ms. Guinn on how bat diet is impacted by the extensive presence of agricultural fields in the Great Plains; specifically, we can couple our sampling efforts to potentially expand Ms. Guinn's sampling area and to look at this federally threatened species.
    - Finally, Dr. Gillam will also work with other Track-1 researchers, specifically those in the UND Department of Atmospheric Science, to bring field data into a geospatial modeling environment to understand how predicted impacts of global climate change will alter the availability of preferred *M. septentrionalis* habitat in the Great Plains.
    - CRCS Leads, Jianglong Zhang and Frank Bowman are working to revise the CRCS' strategic plan objectives to show the addition of Dr. Gillam's research and the integration of research being conducted at the TCs and PUIs. This will be finished by no later than June 30th.

Finally, in a continued effort to link provide additional pathways for a more inclusive environment for projects like those being established at the TCs and PUIs, the membership of the EMPOWERED-ND Corps will be expanded to include:

- ND EPSCoR NSF Track-1 Diversity Lead: Eakalak Khan, and Co-Lead: Chad Ulven

- ND EPSCoR NSF Track-1 Partnerships, Collaborations and Communication Co-Leads: Mukund Sibi, CSMS Co-Lead and Frank Bowman, CRCS Co-Lead

Following the completion of the activities outlined above, the EPSCoR Leadership team will submit to NSF [by no later than August 1, 2016], the updated plan that includes the discussed deliverables. Additionally, any modifications needed to the Strategic Plan will also be submitted for review and approval.

APPENDIX 4.5: June 22, 2016 – NSF acceptance of ND EPSCoR RSV response #3 and request for additional information related to #1, #2 and #4

National Science Foundation
4201 Wilson Boulevard
Arlington, Virginia 22230

June 22, 2016

MEMORANDUM

TO: Kelly Rusch, North Dakota EPSCoR

FROM: Timothy VanReken, EPSCoR Program Director,
Office of Integrative Activities, NSF

SUBJECT: Follow-up on Reverse Site Visit Report Response for Research Infrastructure Improvement Track-1 Award EPS-1355466

Thank you for your response to the panel recommendations from the recent Reverse Site Visit (RSV) that was held on March 17, 2016. The RSV report contained four (4) specific recommendations. NSF EPSCoR has evaluated your plan for addressing these recommendations and the associated materials submitted to date. These responses were largely satisfactory, but some minor outstanding issues require further attention. Below are NSF EPSCoR's comments and requested actions based on materials submitted thus far:

Recommendation 1 – External Communication Planning
The response indicated that the project leadership would create an action plan for improving the project's external communications prior to July 1, 2016. NSF EPSCoR requests that this plan be submitted to the managing Program Officer *via* email prior to July 31, 2016.

Recommendation 2 – External Collaborations and Partnership Planning
The response indicated that the project leadership would create an action plan for improving the project's external collaborations and partnerships prior to July 1, 2016. NSF EPSCoR requests that this plan be submitted to the managing Program Officer *via* email prior to July 31, 2016.

Recommendation 3 – Establishing Sustainable Cross-Institution Collaborations
This response is accepted. Updates on the progress of the activities described should be included in future annual reporting.

Recommendation 4 – Integration of Research at Partner Institutions
The response to this recommendation falls short in addressing the concern that the RSV panel had raised. The panel's view was that while the research being performed at the tribal colleges (TCs) and primarily undergraduate institutions (PUIs) were

beneficial to the project, these projects did not integrate well with the existing strategic plan. The updates to the strategic plan in response to this concern do not correct the problem - assigning a new activity to a particular existing objective does not automatically make it "fit" with that objective. The incongruence remains, and as more researchers from PUIs and TCs join the project, more strategic plan updates would implicitly be required.

The project should work to identify a way to more organically incorporate their approach for integrated TC and PUI researchers into the strategic plan. It need not necessarily be research outcome specific. A possible way to address this is to make the integration of broadly aligned TC and PUI research an explicit part of the CSMS and CRCS long-term visions. This goal of engagement is already captured in Objective 1.4 of Focus Area 4 (Education and Workforce). Broadly aligned PUI and TC research engagement could perhaps also be linked directly to the two centers by adding new objectives to Goal 2 for Focus Areas 1 & 2. In the managing PO's view, these objectives are already implicit in the project's ongoing activities.

Other approaches for addressing this are possible. The project should determine how to proceed and provide an updated response for this recommendation prior to July 31, 2016. The managing PO would welcome a phone discussion on this issue prior to that deadline.

Required Action: An update on the project's progress toward meeting the recommendations will be sent *via* email to the managing Program Officer (Timothy VanReken, tvanreke@nsf.gov) by July 31, 2016. The annual project report, and subsequent reports as necessary, should include information about the activities carried out during each year, the progress made, and the impacts of these activities in addressing all three RSV recommendations.

Continued support through this Cooperative Agreement is contingent upon satisfactory progress on the project, programmatic terms and conditions, and RSV recommendations.

If you have any questions, please feel free to contact your RII Track-1 award's managing Program Officer, Timothy VanReken.

APPENDIX 4.6: July 29, 2016 – Additional ND EPSCoR Response to RSV #1, #2, and #4

From: Jean Ostrom-Blonigen
Sent: Friday, July 29, 2016 4:00 PM
To: 'VanReken, Timothy M.' <TVANREKE@nsf.gov>; Kelly Rusch <kelly.rusch@ndsu.edu>
Cc: Hoffmann, Mark <mark.hoffmann@und.edu>
Subject: RE: Reverse Site Visit Followup

Hi Tim,

Contained in this email are ND EPSCoR's response to your June 28, 2016 correspondence regarding our follow-up to the NSF RSV panel's recommendations #1, #2, and #4; *Recommendation 3 - Establishing Sustainable Cross-Institutional Collaborations* was previously addressed and accepted by NSF:

Recommendation 1 – External Communication Planning - The response indicated that the project leadership would create an action plan for improving the project's external communications prior to July 1, 2016. NSF EPSCoR requests that this plan be submitted to the managing Program Officer *via* email prior to July 31, 2016.

- Attached is ND EPSCoR Action Plan Worksheet for NSF RSV Recommendation #1 which calls for: 1) hiring 2 senior communication research personnel (also see attached specifics regarding reallocations within NSF budgets) to work with the CRCS and CSMS team Leads and co-Leads in better communicating the science of the Centers they lead to external stakeholders via various methods; 2) membership additions to the Partnerships, Collaborations and Communications team; 3) ex-officio membership additions to the EMPOWERED-ND Corps; and 4) hiring of personnel dedicated to bring the CRCS website current (meets the metrics of the strategic plan).

Recommendation 2 – External Collaborations and Partnership Planning - The response indicated that the project leadership would create an action plan for improving the project's external collaborations and partnerships prior to July 1, 2016. NSF EPSCoR requests that this plan be submitted to the managing Program Officer *via* email prior to July 31, 2016.

- Attached is ND EPSCoR Action Plan Worksheet for NSF RSV Recommendation #1 which calls for: 1) the development of a tracking spreadsheet derived from ND EPSCoR's ERcore database; 2) quarterly reviews of the tracking spreadsheet by CRCS and CSMS team Leads and co-Leads for the purpose of completing records and establishing contact assignments; and 3) semi-annual reviews of social networking analysis maps (similar to those used during the 2015 NSF Annual Conference) by CRCS and CSMS team Leads and co-Leads for the purpose of measuring collaboration relationships.

Recommendation 4 – Integration of Research at Partner Institutions - The response to this recommendation falls short in addressing the concern that the RSV panel had raised. The panel's view was that while the research being performed at the tribal colleges (TCs) and primarily undergraduate institutions (PUIs) were beneficial to the project, these projects did not integrate well with the existing strategic plan. The updates to the strategic plan in response to this concern do not correct the problem - assigning a new activity to a particular existing objective does not automatically make it "fit" with that objective. The incongruence remains, and as more researchers from PUIs and TCs join the project, more strategic plan updates would implicitly be required.

- Attached is ND EPSCoR's revised Strategic Plan (with tracking, so that you can see the changes). Added to CRCS and CSMS Goal#1, Objective #2.1 is a benchmark activity to continually seek to identify, initiate, integrate and foster research collaborations with faculty from partner institutions (TCs and PUIs).

Thank you – please let me know if you have any questions.

Have a great weekend,

Jean Ostrom-Blonigen, Ph.D., CPA
ND EPSCoR Project Administrator

1735 NDSU Research Park Drive
NDSU Dept. 4200, P.O. Box 6050, Dept. 4200 / Fargo, ND 58108-6050
p: 701-231-7516 / *www.ndepscor.ndus.edu*

Action Plan Worksheet

Jurisdiction: North Dakota

Objective: Develop a plan for improving the [Track-1] project's external communications, including traditional media engagement, social media, and web presence

Why this objective is important: In its March 2016 review of ND EPSCoR's NSF Track-1 program, the Reverse Site Visit (RSV) panel felt that broader impacts could be achieved via an improved, systematic, proactive external communications strategy

Action *Be activity-focused*	**Responsible Party(s)** *Identify the driver*	**Resources** *Who should participate?*	**Outcomes** *Be realistic, specific, measurable*	**Time Frame** *When should it be done?*
Add professional support and/or senior personnel for Track-1 project science communication *(requires NSF approval to re-budget)*	PD, Associate PD, and PA	Partnerships, Collaborations and Communication leads: Mukund Sibi and Frank Bowman EMPOWERED-ND Corps Chair: Scott Hanson	Track-1 Science communication participant(s) added to project	As soon as possible in Y3 (August 1, 2016 – July 31, 2017)
Add the following members to the Partnerships, Collaborations and Communication team: - Erin Gillam (CRCS) – new Track-1 researcher identified in ND EPSCoR's response to NSF RSV recommendations #3 and #4 - Alena Kubatova (CSMS) – new Track-1 researcher identified in ND EPSCoR's response to NSF RSV recommendations #3 and #4 - Scott Hanson, TC Liaison manager and EMPOWERED-ND Chair - Science communication personnel added in prior activity	Partnerships, Collaborations & Communication leads: Mukund Sibi and Frank Bowman	N/A	Increase partnerships, collaborations & communications with TCs and PUIs	Immediately
Consider other additions to the Partnerships, Collaborations and Communication team; currently comprised of: Bret Chisholm, Anne Denton, Erin Gillam, Scott Hanson, Mark Hoffmann, Alena Kubatova, Jean Ostrom-Blonigen, Kelly Rusch, Chad Ulven, Dean Webster, Jianglong Zhang, and science communication senior personnel	Partnerships, Collaborations & Communication leads: Mukund Sibi and Frank Bowman	Partnerships, Collaborations and Communication team EMPOWERED-ND Corps members	Increased opportunities for partnerships and collaborations	Immediately
Develop an on-going series of Track-1 activities designed to inform, educate, and persuade the citizens of ND, the region, and the nation about the areas of project excellence	Track-1 science communication senior personnel	Partnerships, Collaborations and Communication team EMPOWERED-ND Corps members	Improved, systematic, and proactive external communications strategy for the Track-1	From date added as Track-1 participant to end of current Track-1 award

Action Plan Worksheet

Action *Be activity-focused*	**Responsible Party(s)** *Identify the driver*	**Resources** *Who should participate?*	**Outcomes** *Be realistic, specific, measurable*	**Time Frame** *When should it be done?*
Use mass media, publications, on-line technologies, audio and video productions, etc. to facilitate two-way communication between the Track-1 project and it publics: - External publics (i.e., NSF, other EPSCoR jurisdictions, legislators, state board of higher education, community residents and business leaders, news media, friends, taxpayers) - Internal publics (i.e., ND university system and faculty, staff, students of research universities: NDSU, UND, tribal colleges: CCCC, NHSC, SBC, TMCC, UTTC, and primarily undergraduate institutions: DSU, MaSU, MiSU, DSU)	Track-1 science communication senior personnel	Partnerships, Collaborations and Communication team EMPOWERED-ND Corps members	Closer coordination between Track-1 and the communication resources at all 11 participating institutions for the purpose of communicating Track-1 science to stakeholders	From date added as Track-1 participant to end of current Track-1 award
Develop the voice of and identity in all Track-1 participants in an effort to build ND EPSCoR's reputation and image	Track-1 science communication senior personnel	All Track-1 participants	Improved awareness among Track-1 stakeholders	From date added as Track-1 participant to end of current Track-1 award
Specific to the activities of the Track-1, review ND EPSCoR websites (ND EPSCoR, NATURE, CSMS, CRCS) for the 5C's of design with group responsible for website maintenance	Track-1 science communication senior personnel	CSMS: Dean Webster, Mukund Sibi, Kathy Wahlberg CRCS: Jianglong Zhang, Frank Bowman, person hired for CRCS website ND EPSCoR: PD, Associate PD, and PA NATURE: Eakalak Khan, Robert Pieri, Chad Ulven, NATURE intern, Kathy Wahlberg Other Track-1 focus area leads	Track-1 communication will be clear, concise, correct, coordinated and complete	From date added as Track-1 participant to end of current Track-1 award
Hire dedicated personnel to manage the ND EPSCoR Track-1 Center for Regional Climate Studies (CRCS) website	Associate PD: hire/supervise CRCS leads/ researchers: provide content	Person hired for CRCS website	Pass audit by external reviewer	Y3, Y4, Y5
Continue to use dedicated personnel to manage the ND EPSCoR Track-1 Center for Sustainable Materials Science (CSMS) website	PA: supervise CSMS leads / researchers: provide content	Kathy Wahlberg	Continue to pass audit by external reviewer	Y3, Y4, Y5

Action Plan Worksheet

Action *Be activity-focused*	**Responsible Party(s)** *Identify the driver*	**Resources** *Who should participate?*	**Outcomes** *Be realistic, specific, measurable*	**Time Frame** *When should it be done?*
Hold quarterly meetings of Partnerships, Collaborations and Communication team to discuss progress toward Track-1 metrics	Partnerships, Collaborations and Communication leads: Mukund Sibi and Frank Bowman	Partnerships, Collaborations and Communication team	Increase awareness of Track-1 responsibilities in this focus area	Beginning Y3
Using ERcore, provide PD, Associate PD and PA with biannual mitigation plans for Partnerships, Collaborations and Communication metrics that are behind schedule	Partnerships, Collaborations and Communication leads: Mukund Sibi and Frank Bowman	Partnerships, Collaborations and Communication team	Improve status of Track-1 metrics	July 31 of each year of the award January 31 of each year of the award

Action Plan Worksheet

Jurisdiction: North Dakota

Objective: Specify a set of specific objectives for improving the project's external collaborators and partnerships

Why this objective is important: In its March 2016 review of ND EPSCoR's NSF Track-1 program, the Reverse Site Visit (RSV) panel felt that the project team would benefits substantially from strong ties with external collaborator and other partners

Action *Be activity-focused*	**Responsible Party(s)** *Identify the driver*	**Resources** *Who should participate?*	**Outcomes** *Be realistic, specific, measurable*	**Time Frame** *When should it be done?*
Develop an ERcore spreadsheet of Track-1 partners/collaborators that lists: - Research Partner/collaborator: Company; Contact; Location; Description of partnership/collaboration - Track-1 participant(s) who is/are responsible for tending the relationship: Name; Center Affiliation; Need for a conflict management plan, including whether an approved plan is on file; - Internship program with Partner/collaborator: Contact; Intern; Whether there is a Track-1 research relationship to the internship, Description of internship; Whether a STTAR internship	Kathy Wahlberg Laura Slicer Cathy Lerud Carla Kellner	ND EPSCoR staff Douglas Tschetter, ERcore developer	Spreadsheet will: - Highlight incomplete entries - Identify potential collaboration opportunities - Improve metric tracking in this focus area	First quarter of Y3
From the ERcore spreadsheet (described above), identify incomplete records in ERcore and work with Track-1 CRCS and CSMS Leads to ensure that participant data is complete	Partnerships, Collaborations and Communication leads: Mukund Sibi and Frank Bowman	Partnerships, Collaborations and Communication team All Track-1 CRCS and CSMS participants	Improved ERcore data base will assist with reporting and improve metric tracking in this focus area	Quarterly beginning in Y3
Using the ERcore spreadsheet (described above) discuss the status of and identify the potential for Track-1 partnerships/ collaborations; including: - Prior Action item(s) - Track-1 participant(s) responsible for prior Action item(s) - Status of prior Action item(s) - Current decision regarding prior Action item(s) - Action item(s) for next period - Track-1 participant(s) responsible for next period's Action item(s)	Partnerships, Collaborations and Communication leads: Mukund Sibi and Frank Bowman	Partnerships, Collaborations and Communication team	Quarterly review of data will document progress toward metrics	Quarterly beginning in Y3
Develop a social network analysis to map and measure the relationships and flows between ND EPSCoR's Track-1 collaborators	Partnerships, Collaborations and Communication leads: Mukund Sibi and Frank Bowman	ND EPSCoR PA NDSU Group Decision Center	Quarterly review of data will document progress toward metrics	Twice each year beginning in Y3

APPENDIX 4.7: September 9, 2016 - NSF acceptance of ND EPSCoR RSV response #1, #2, #4 and revised Strategic Plan

National Science Foundation
4201 Wilson Boulevard
Arlington, Virginia 22230

September 9, 2016

MEMORANDUM

TO: Kelly Rusch, ND EPSCoR

FROM: Timothy VanReken, EPSCoR Program Director,
Office of Integrative Activities, NSF

SUBJECT: Final follow-up on Reverse Site Visit Report Response for Research Infrastructure Improvement Track-1 Award OIA-1355466

Thank you for your responses to the panel recommendations from the recent Reverse Site Visit (RSV) that was held on March 17, 2016. The RSV report contained four (4) specific recommendations. NSF EPSCoR has evaluated your responses (dated May 20, 2016, July 29, 2016, and August 25, 2016) to the recommendations and determined that they are acceptable.

The annual project report, due on May 2, 2017, and subsequent reports as necessary, should include information about the activities carried out during each year, the progress made, and the impacts of these activities in addressing all four RSV recommendations.

Continued support through this Cooperative Agreement is contingent upon satisfactory progress on the project.

If you have any questions, please feel free to contact your RII Track-1 award's managing Program Officer, Timothy VanReken.