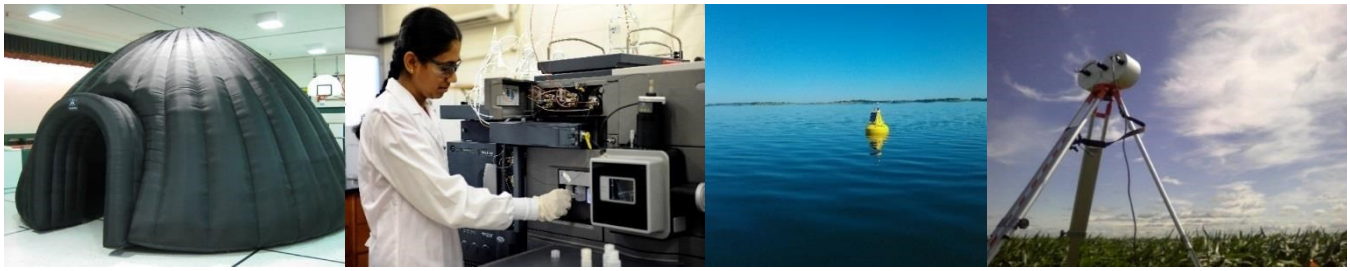

Innovative and **S**trategic **P**rogram **I**nitiatives for **R**esearch and **E**ducation-**N**orth **D**akota
INSPIRE North Dakota

NSF EPSCoR RII Track-1 Strategic Plan 2014-2019

OFFICIAL START DATE: August 1, 2014 **EXPIRATION DATE:** June 30, 2021
AWARD NUMBER: IIA-1355466

AGAIN REVISED (March 1, 2018): following acceptance of January 2018 NSF Site Visit Panel Recommendations Response

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

ND EPSCoR
Established Program to Stimulate Competitive Research

List of Major Strategic Plan Revisions approved by NSF during August 2017 Site Visit (RSV):

Changes made in response to Site Visit recommendations:

- Recommendation #1 - *Viability of Center for Regional Climate Studies (CRCS)*
  - ND EPSCoR CRCS assessed and redefined its mission statement defining themselves as a group that does basic science research, which can be applied to regional stakeholders within the scope of the atmospheric, agriculture, biology, and hydrology fields. CRCS also added two NDSU researcher to its project and formed a Stakeholder Advisory Board (see Objective 2.5)
- Recommendation #2 – *Future Work of Center for Sustainable Materials Science (CSMS)*
  - ND EPSCoR CSMS added an additional NDSU researcher and outlined a sustainability plan.
- Recommendation #3 - *Viability of Diversity Programming*
  - ND EPSCoR clarified the difficulties we face with American Indian programming and requested that the current programs be allowed to stand.
- Recommendation #4 - *Direction of Education and Workforce Development)*
  - ND EPSCoR agreed to be more intentional about its educational outreach activities in additional to its educational outreach activities.
- Recommendation #5 - *Access to CRCS data*
  - CRCS outlined its plans for both its observational data for the ND region and it stakeholder decision data.

Changes in Committee memberships:

- Under the direction of the ND University System, ND EPSCoR's bylaws were reconstituted to provide increased alignment with NSF's vision for this state committee:
  - Richard Rothaus, Vice Chancellor for Academic and Student Affairs, ND University System was named the Chair
  - State Advisory Board was eliminated. Industry and legislative members on State Advisory Board became members of the State Steering Committee:
    - Industry:
      - Thomas Shorma replaced by Randy Gerhold
    - Legislative:
      - Kathy Hawkin replaced by Thomas Beadle
      - Mac Schneider replaced by Carolyn Nelson replaced
  - Tribal college (TC) and primarily undergraduate institution membership was maintained at one each (Twyla Baker-Demaray and Andre DeLorme).
  - NDSU and UND faculty members were replaced by members from other state sectors:
    - Research – 4 members (Sheri Anderson, Chuck Hoge, Grant McGimpsey, and Vacant)
    - ND Department of Public Instruction (Matthew Scherbenske)
    - ND Department of Commerce (Jay Schuler)
- External Advisory Board (EAB)
  - James Kenar agreed to Co-Chair the EAB
  - Sonia Kreidenweis was replaced by Lynn Russell

Changes in Participants:

- Change in Project Co-PI:
  - Mark Hoffmann replaced by Barry Milavetz

- Changes in Center for Regional Climate Studies (CRCS):
    - Frank Bowman, who became Department Chair, will continue his CRCS research, but not his CRCS leadership role. Bowman was replaced by Aaron Kennedy and David Roberts as CRCS research Co-Lead. Bowman
    - Cindy Juntunen, who became the Dean of her College was replaced by Tamba-Kuii Masai Bailey. However, Juntunen has agreed to continue to advise her junior colleague in these CRCS research efforts throughout the duration of the award
    - Carrie Ann Duafala and Michael Parker replaced Brent Voels.
        - Duafala subsequently left CCCC
    - Lauren Dennhardt replaced Casey Williams
    - Additions as a result of the NSF Site Visit recommendations:
        - Adnan Akyuz
        - David Franzen
- Changes in Center for Sustainable Materials Science (CSMS):
    - Addition of final New Hires
        - Bakhtiyor Rasulev (Computational Polymer Science)
        - Ghasideh Pourhashem (Life Cycle Assessment)
    - Additions as a result of the NSF Site Visit recommendations
        - Marisol Berti
    - Bashir Khoda replaced Jayaraman Sivaguru
- Changes in Diversity
    - Eakalak Khan replaced by Scott Hanson – this change represents a collapse in one of the NATURE administrative levels as the result of a decrease in ND state budgets
    - Julia Bowsher and Britt Heidinger replaced Chad Ulven as the ND EPSCoR NATURE Sunday Academy Co-cordinators
    - Native American Success in Science and Engineering (NASSE) personnel hired:
        - Tyson Jeannotte at UND in Y3
        - Ruth Buffalo at NDSU in Y4
- Changes in Education and Workforce Development
    - Cindy Juntunen, who became the Dean of her College was replaced as co-Lead by Ashley Hutchison. However, Juntunen has agreed to continue to advise her junior colleague in these education research and outreach efforts throughout the duration of the award
    - Cindy Juntunen, who became the Dean of her College was replaced by Ryan Summers. However, Juntunen has agreed to continue to advise her junior colleague in these education research and outreach efforts throughout the duration of the award
    - Siji Saula, who served in an interim role after Martin Ossowski left NDSU was replaced by Dane Skow
    - The ND EPSCoR State Office is currently screening for a new position: STEM Manager
- Changes in Partnerships, Collaborations and Communication
    - Frank Bowman, who became Department Chair, will continue in his CRCS liaison role, but not his leadership role. Bowman was replaced by Michael Moore as Partnerships, Collaborations and Communication Co-Lead
    - Joyce Eisenbraun, ND EPSCoR State Office's new Communication Manager, will begin working with the team on dissemination of information to all stakeholders and audiences on February 12, 2018

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 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.
- 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. Barry Milavetz**, Associate Project Director and Co-Principal Investigator, UND
- **Dr. Jean Ostrom-Blonigen**, Project Administrator and Co-Principal Investigator, NDSU

ND EPSCoR Steering Committee:

- **Dr. Richard Rothaus,** ND EPSCoR State Steering Committee **Chair** and Vice Chancellor for Academic and Student Affairs, ND University System
- **Ms. Sheri Anderson**, Associate Vice President for Research Development, NDSU
- **Dr. Twyla Baker-Demaray**, President, Nueta Hidatsa Sahnish College
- **Representative Thomas Beadle**, Fargo
- **Representative Lois Delmore**, Grand Forks
- **Dr. Andre DeLorme**, Professor and Chair, Department of Science, Valley City State University
- **Mr. Randy Gerhold,** Partner Engineering Manager, Microsoft
- **Mr. Chuck Hoge**, Executive Director, NDSU Research and Technology Park
- **Senator Raymon Holmberg**, Grand Forks
- **Dr. Grant McGimpsey**, Vice President for Research and Economic Development, UND
- **Dr. Barry Milavetz**, Associate Project Director and Co-Principal Investigator, UND, ex-officio
- **Senator Carolyn Nelson,** Fargo
- **Dr. Jean Ostrom-Blonigen**, ND EPSCoR Project Administrator, NDSU, ex-officio
- **Dr. Kelly A. Rusch**, P.E., ND EPSCoR Project Director, Vice President, Research and Creative Activity, NDSU and ND Representative to Coalition of EPSCoR States*, ex-officio
- **Mr. Matthew Scherbenske,** Assistant Director, Office of Academic Support, ND Department of Public Instruction
- **Mr. Jay Schuler**, Commissioner, ND Department of Commerce
- **Vacant,** UND Center for Innovation

External Advisory Board:

- **Dr. Kathryn Uhrich**, **EAB Chair** and Dean, College of Natural and Agricultural Sciences, University of California - Riverside
- **Dr. James Kenar**, **EAB Co-Chair,** Research Chemist, United States Department of Agriculture, Agricultural Research Service, Peoria
- **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. Amy Landis**, Professor/Endowed Chair, Glenn Department of Civil Engineering and Director, Institute for Sustainability, Clemson University
- **Dr. Lynn Russell**, Professor, Atmospheric Chemistry, Scripps Institution of Oceanography, University of California
- **Dr. Yannick Huot**, Associate Professor, Applied Geomatics Department, University of Sherbrooke

North Dakota EPSCoR Office
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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 **PrO**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 team in Dr. LaVallie's 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.]

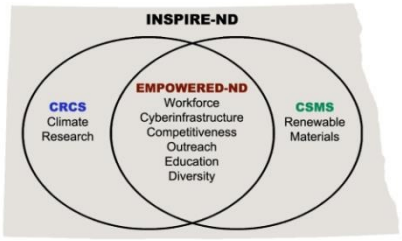
3. INSPIRE-ND Strategic Plan

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

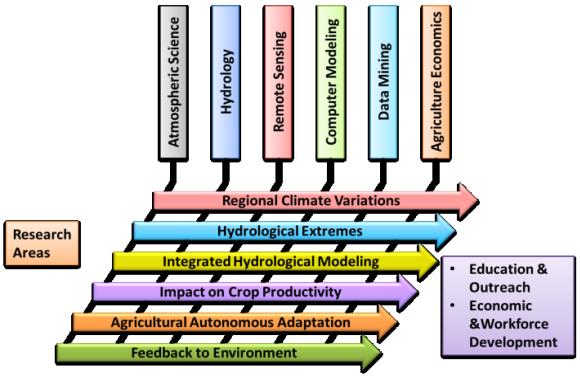
- Team participants and partners
- Key outcome(s)

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)

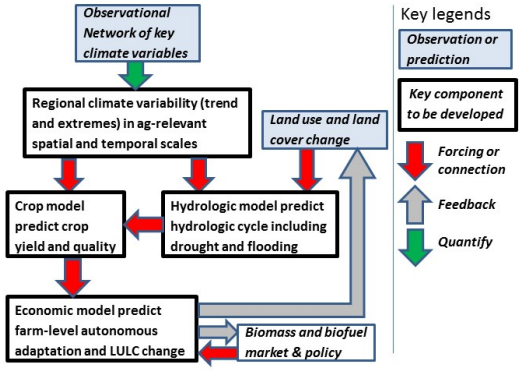
Strategic Priority: North Dakota, recognized as a major sustainable supplier of food crops and biofeedstocks, seeks to continue and advance that ranking through an increased understanding of regional climate patterns.



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).



Mission Statement: The Northern Great Plains is one of the most agriculturally productive areas in the world. It is a region with documented extremes in weather. Floods, droughts, and other weather hazards occur commonly and pose risks to the region's residents and agricultural based economy. The goal of the CRCS is to study the impacts of weather and regional climate variations on regional properties such as the hydrological cycle, extreme weather events, agricultural land use, crop production, and resultant impacts on the economy. The center emphasizes the building of cross-disciplinary collaborations between regional institutions such as UND, NDSU, TCs, and PUIs to tackle complex studies that meld data from field measurements, remotely-sensed platforms, and various numerical models. Center activities emphasize projects that not only advance broad scientific knowledge, but also have outcomes that benefit regional stakeholders.

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 five 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*).

- Build connections with regional stakeholders to prioritize active research projects and data dissemination, facilitate collaborations with the region, and guide future research activities within the center. A Stakeholders Advisory Board will be created and engaged to obtain feedback on research and products produced (*objective 2.5*).

Team Leads: CRCS co-Lead, **Jianglong Zhang** (Associate Professor, Atmospheric Sciences, UND), is an expert in satellite remote sensing of atmospheric aerosols and data assimilation. The CRCS co-Lead, **Aaron Kennedy** (Assistant Professor, Atmospheric Sciences, UND) is an expert in climate modeling and data processing. The CRCS co-Lead, **David Roberts** (Assistant Professor, Agribusiness and Applied Economics, NDSU) conducts econometric analysis on the impacts of agricultural production methods on environmental resources.
The research center members will leverage and interact with all other program components, the primarily undergraduate state universities, tribal colleges, businesses, local and national media, other potential research partners and governmental agencies.

Team Participants and Partners:
- **Adnan Akyuz** (North Dakota State Climatologist, NDSU) disseminates climate information to the state.
- **Crystal Alberts** (Associate Professor, English and Director of Writers Conference, UND) communicates the science of the center.
- **Tamba-Kuii Masai Bailey** (Assistant Professor, Counseling Department) studies vocational psychology of rural and underrepresented groups.
- **Frank Bowman** (Associate Professor, Chemical Engineering, UND), studies atmospheric aerosols and also conducts research on assessment of K-12 STEM outreach.
- **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.
- **Lauren Dennhardt** (Assistant Professor, Science, VCSU) studies the effects of climate on native and invasive grasses.
- **Anne Denton** (Associate Professor, Computer Science, NDSU) is an expert in data mining of complex environmental and agricultural data sets.
- **David Franzen** (Extension Soil Specialist, NDSU) performs soil research and provides soil and planting recommendations information to the public.
- **Erin Gillam** (Associate Professor, Biological Sciences, NDSU) researches the behavioral ecology of bats 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** (Dean and Professor, Counseling, UND) serves as a research liaison/mentor to the farmer studies CRCS team members.
- **Michael Parker** (Instructor, Pre-Engineering / Math, CCCC) studies impact of oil spill impacts on ag-economy.
- **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.
- **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.	Apply GCM data for hydrological and crop modeling 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.		
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).	
Study regional climate extremes				Study regional climate extremes using observed and simulated data.	Link regional climate extremes with agricultural studies.
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/**)					
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 a crop model.	Review updating 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.	Iidentify scenarios of crop change.	Perform model simulations; analyze 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/Bailey/Roberts/Zheng/Parker/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 agricultural models.	Integration with IHM and climate data.
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/Dennhardt)**					
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//Roberts/Kennedy)**					
Build the CRCS team by holding meetings that include postdocs and graduate students. **(J. Zhang/ Roberts/Kennedy)**	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). **(All CRCS researchers/Bergstrom/ Skow)**					
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/Skow)**					
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/Skow)**					
Procure HPC equipment.	Determine need for additional HPC equipment. Determine available funding for HPC equipment. Make purchase decision.	Procure equipment as needed.	Ongoing.	Ongoing.	Refresh previously purchased equipment if needed and budgets allow.
Objective 2.5: Develop and foster interactions between CRCS researchers and regional stakeholders **(Kennedy/Roberts/Denton/J. Zhang/X. Zhang/ChuAkyuz/Franzen)**					
Develop Stakeholders Advisory Board				Create Stakeholders Advisory Board. Meet regularly and solicit feedback from board.	Ongoing.

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)**	**Year 3 (through March 15, 2017)**	**Five-Year Cumulative Targets**
Number of statistically downscaled Global Climate Models (GCM) for the Northern Great Plains	0	22	0 *(unless determined necessary, this metric (as described in the Kirilenko mitigation plan) will no longer be tracked)*	20
Number of dynamically downscaled Global Climate Models (GCM) for the Northern Great Plains	0	2	2	2
Number of new algorithms or models for understanding parts of regional climate variation	1	3	4	7
Number of integrations of Northern Great Plains data with widely used data sets	0	1	0	3 **(M1)**
Number of data sets shared through web	N/A	N/A	N/A	NEW Metric following Y4 Site Visit 3
Number of farmer focus groups	0	2	0	2
Number of farmers surveyed	N/A	20	137 *(additional 200 est. in Year 3)*	720
Globus Online Implementation	Determine need	Integrated	Integrated	Integrated
RDBMS minicloud	Match needs to funding	Pending	Pending	Developed **(M2)**
HPC Equipment for CRCS activity	Determine need	Integrated	Integrated	Integrated
Total number of peer-review publications related to CRCS topics	17	28	16	93

Number of collaborative peer-review publications (more than one senior author)	5	24	-25 *(there are a total of 4 at this time* **(M3)**	60
Number of peer-reviewed publications with TC and/or PUI co-authors	0	7	8	5
Number of peer-review publications acknowledging support from this grant			21	45
~~Total number of conference presentations relate to CRCS topics~~	~~19~~	~~50~~	~~23~~	~~90~~
Total number of submitted research proposals related to CRCS topics	8	22	12	~~71~~ 50
Number of submitted collaborative proposals	4	18	-18 *(there a total of 4 at this time)* **(M3)**	Metric reduced following NSF Site Visit 10
Number of submitted research proposals (collaborative research between UND and NDSU)	0	0	0	9 **(M4)**
Number of collaborative proposals with TC and/or PUI co-investigators	0	0	0	6 **(M5)**
Total external research funding (million $) – 5-year total is cumulative	$.04M	$2.1M	$2.75M	$4.0M*
Number of postdoctoral Students trained	1	5	-3 (the same postdoc has received training each year) **(M6)**	Metric reduced following NSF Site Visit 3
Number of graduate students trained	18	22	64	70
Number of undergraduate students trained	5	10	22	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	$90,168 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	$169,624 Direct	$531,000 Total

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

Mitigation Plans for CRCS Metrics that are currently listed as behind schedule:

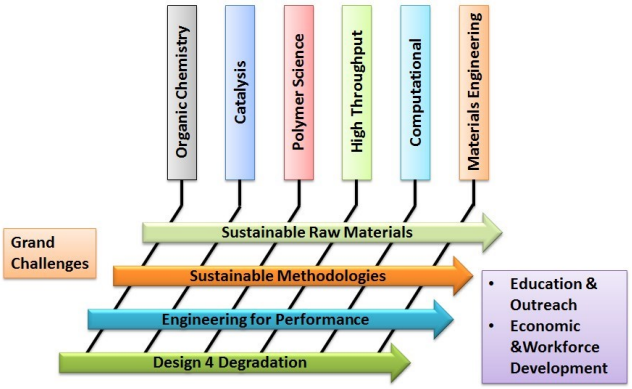
- **M1:** (*Number of integrations of Northern Great Plains data with widely used data sets*): A variety of measurement data is now being collected by project researchers and is already being shared on a limited basis with external collaborators. In the coming year we will work to prepare and make available these data sets to the broader scientific community.
- **M2:** (*RDBMS minicloud*): We have ongoing negotiations on hosting the RDBMS minicloud with the NDSU IT Division, considering that the Center for Computationally Assisted Technology may not have the staff to host it as originally planned. The IT Division has, in recent years, increasingly made virtual servers available to faculty. They were not offering such services when the grant was written. It has been suggested that the system be built at the department of Computer Science at NDSU. Currently, the NDSU computer science department is down to a half time sys admin position. A recruitment effort for a sys admin position (Denton is in the search committee) is ongoing and will likely solve the issue.
- **M3:** [*Number of collaborative peer-review publications (more than one senior author) / Number of submitted collaborative proposals]* Our Year 3 metric audit showed that CRCS over-reported these metrics by 25 and 18; respectively. It appears that any collaborative publication or proposal that was collaborative was added as a count toward the metric independent of its tie of CRCS; thus the majority of past reporting was on topics unrelated to either of the research cluster themes. However, this metric was not originally interpreted as 2 CRCS senior authors/participants or as 1 CRCS and 1 CSMS senior author/participant. ND EPSCoR is clarifying this interpretation in this manner because the limited internal collaboration within CRCS and between CRCS and CSMS was also evidenced in the NSF RSV Recommendation #3 and in the CRCS External Collaboration Network Map prepared by our External Evaluator. ND EPSCoR believes that this issue is a symptom of a newly formed team and that it will soon begin to resolve itself, which is why we have recorded these metrics as "on schedule" and will revisit them again prior to the NSF site visit in August 2017. *This metric will be reviewed with our NSF Program Director to determine if the five year target should be reduced.* ***This metric was reduced from 31 to 10 following the NSF Site Visit.***
- **M4:** (*Number of submitted research proposals (collaborative research between UND and NDSU*): Since this metric was reported as behind schedule at the March 2016 NSF RSV, several steps have been taken to increase collaborative research proposals. Both NDSU and UND have initiated seed-grant programs for collaborative research projects that bridge CRCS and CSMS themes and that require collaboration with current TC or PUI participants. Three collaborative proposals received funding from this initiative at NDSU, while UND has recently completed their evaluation of seed-grant proposals and will release their emerging seed awards soon. These one-year seed grant projects are designed to generate preliminary data for funding proposals to NSF, and awardees are expected to submit at least

one such proposal during, or shortly after, the award period. Two additional researchers were added to the two research clusters to help build additional cross-institutional and cross-center ties. Alena Kubatova (Chemistry, UND), was added to CSMS. Kubatova has existing research relationships with several of the current CSMS and CRCS researchers at NDSU, NHSC, TMCC, and UND. Erin Gillam (Biological Sciences, NDSU) was added to the CRCS team. Gillam has existing relationships with the CRCS researchers at DSU and UTTC. As a part of the quarterly all-participant meetings, we have begun conducting networking sessions where participants from different campuses and/or research clusters are able to learn more about each other's research interests and capabilities, with the goal of fostering new collaborations. During the remainder of the monthly CRCS meetings, we will spend time generating a list of potential collaborative projects and collaborators and will then follow up with the researchers to encourage and assist with submitting proposals.

- **M5:** (*Number of collaborative proposals with TC and/or PUI co-investigators*): So far TC and PUI investigators have focused their limited research time on initial data collection and analysis. Now that their projects are up and running they are in a better position to prepare collaborative proposals with other CRCS researchers, using their results as preliminary data for such proposals. Since this metric was reported as behind schedule at the March 2016 NSF RSV, the mitigation steps that have been taken above for item M3 will also support submission of collaborative proposals with TC and PUI researchers.
- **M6:** (*Number of postdoctoral Students trained*): Thus far, only one postdoctoral student has been trained within this grant. This is due to difficulties recruiting qualified postdocs for the project. To compensate for this (as evidenced in our graduate and undergraduate "students trained" numbers), we have increased graduate and undergraduate student participation on the project. *This metric will be reviewed with our NSF Program Director to determine if, like our CSMS counterpart did at the end of Year 2, CRCS can eliminate its requirement to hire postdoctoral students now that our graduate students are trained.* ***This metric was reduced from 10 to 3 following the NSF Site Visit.***

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 in ND, 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:

- **Marisol Berti** (Professor, Plant Science, NDSU) is an expert in forage and biomass crop production to understand viability of crops for industrial uses.
- **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.
- **Bashir Khoda (**Assistant Professor, Industrial & Manufacturing Engineering, NDSU) studies additive manufacturing (3D printing) of materials.
- **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.
- **Ghasideh Pourhashem** (Assistant Professor, Coatings & Polymeric Materials, NDSU) carries out life-cycle assessments of bio-based materials.
- **Mohiuddin Quadir** (Assistant Professor, Coatings & Polymeric Materials, NDSU) studies bio-based polymer synthesis.

- **Bakhtiyor Rasulev** (Assistant Professor, Coatings & Polymeric Materials, NDSU) carries out research in the field of computational structure-property relationships in polymer materials.
- **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.).
Identify potential industrial crops suitable for North Dakota and the region. Identify industrial value-added products derived from these crops. **(Berti/ Pourhashem)**	N/A.	N/A.	N/A.	Provide seed grant to Marisol Berti and team. Initiate evaluation of industrial crops.	Provide assessment of potential industrial crops, issues with cultivation in ND and the region, and utility as inputs in manufacturing bio-based polymers and composites.
Objective 1.3: Engineer high performance polymers and composites from bio-based raw materials. Benchmark against current appropriate petrochemical counterparts. **(Voronov/Quadir/Bobylev/Rasulev)**					
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	Characterize physical and biophysical properties of synthesized polymers.	Continue effort with new monomers as they become available from the consortium (Sibi).	Comparison of efficiency of the synthesized materials with existing standard, and adjusting

		monomers such as FDCA (Sibi) and ESS. (Epoxydized sucrose soyate).	Evaluation of toxicity and immunogenic properties of these biobased functional polymers in cells and animal models.	Identifying facile and scalable synthetic routes and assembly methods to generate value-added materials and products from these biobased polymers.	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).
Carry out computational investigation of new bio-based polymers to predict properties and assess physico-chemical and biological properties **(Rasulev)**	N/A – New Hire in Y3	N/A – New Hire in Y3	Work with CSMS polymer scientists (Voronov/Webster/Quadir) to obtain compositional and property data of bio-based polymer systems. Identify systems most suitable for computational modeling.	Carry out computational characterization of physical, mechanical and biological (toxicological) properties of the polymers.	Develop predictive computational models to assess physico-chemical, mechanical and biological properties of new polymers.
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/Khoda)**					
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.
Prepare and characterize novel photo curable biobased acrylated resin materials for 3D printing (Webster/Khoda)	N/A – New to team in Y4.	N/A – New to team in Y4.	N/A – New to team in Y4.	Design and develop a UV laser based Stereolithography system for biobased acrylated resin materials (developed by collaborators in the CSMS team). Develop a data thread for	Design and fabricate specimens following the data protocol. Evaluate the mechanical properties (compressive and tensile strength) of the specimens.

				smooth transition of information between virtual (CAD) and physical (3d printer) system.	
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. **(Sibi/Voronov/Mongoh/Rasulev)**					
Develop new biomass derived	Continue efforts in the synthesis	Explore routes to the synthesis	Synthesize and evaluate photo-	Broaden approaches to	Elucidate the mechanism of

phototriggers and photoinitiators that can be incorporated into polymers; synthesize building blocks that can be used to trigger polymer degradation.	of phototriggers; conduct degradation and mechanistic studies of phototriggers.	of novel phototriggers from biomass and evaluate approaches.	initiators for their ability to photoinitiate radical polymerization derived from biomass.	alternative phototriggers and photoinitiators from biomass and evaluate.	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, Webster, Voronov)	Optimize microbial degradation of thermosets. (Webster)	Expand and optimize microbial degradation technique to other types of polymers. Synthesized by CSMS researchers (Sibi, 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.
Use computational methods to study degradable links in polymers. **(Rasulev)**	N/A – New Hire in Y3.	N/A – New Hire in Y3.	Work with CSMS polymer scientists (Sivaguru/Sibi/Voronov/Webster) to obtain compositional and property data on polymers with programmed degradation capability. Identify computational	Investigate the mechanisms of degradation in polymeric systems and biopolymers by computational methods.	Develop predictive models to assess degradation capability for new polymeric systems.

			methods and model polymer systems to study degradable links.		

Objective 1.10: Incorporate triggerable building blocks into polymers and thermosets in order to yield polymers with programmed degradation capability. **(Webster/ 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)**					
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	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.

	distribute to TCs and PUIs.				
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 4.2 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;	Determine purchasing budget and meet with CSMS team members to	Initiate purchases and complete those that are started. Train users (faculty,	Develop protocols for sharing analytical equipment.	Document usage, maintain equipment and plan for	Include additional equipment in CSMS research proposals; plan for the future.

acquire equipment, make operational and utilize.	develop time-based plan.	students and postdocs).		additional equipment.	
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/Skow)**					
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/Skow)**					
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)**	**Year 3 (through March 15, 2017)**	**Five-Year Cumulative Targets**
Number of new synthesized new monomers	23	22	40	40
Number of new thermoset polymers	32	56	54	20
Number of new synthesized vinyl ether monomers	7	5	0	18
Number of synthesized new polyamides	4	0	10	12
Number of synthesize new polyesters	15	4	14	12
Number of synthesize inorganic catalysts	5	3	8	18
Number of high performance thermosets evaluated	19	87	77	12
Number of resin formulations developed	6	13	55	12
Number of bio-based composites	6	3	12	10
Number of synthesized reinforcement polymers	4	3	4	15
Number of synthesized phototriggers-photo initiators	4	2	9	15
Number of new polymers for photodegradation studies	2	1	7	12; reduced to 10 with loss of Sivaguru
Number of composites for photodegradation studies	N/A	N/A	1	6; reduced to 1 with loss of Sivaguru
Number of bio-based polymer formulations printed and characterized	N/A	N/A	N/A	NEW Metric following Y4 Site Visit: 10
Assessment of industrial crops completed	N/A	N/A	N/A	NEW Metric following Y4 Site Visit: 1
Globus Online Implementation	N/A	Determining need	Determining need *(decision is to be made by new computational hire)*	Integrated **(M1)**

HPC Equipment for CSMS activity	N/A	Determining need		Integrated **(M1)**
Number of submitted collaborative proposals	5	5	0	15
Number of new hires	2	0	1	4
Number of CAREER proposals submitted	0	0	0	2-4
Number of new analytical instruments acquired	0	4	4	2
Number of postdoctoral associates trained	5	7	0 *(NSF-approved change to substitute students for postdocs beginning in Y3)*	7
Number of graduate students trained (some may be counted in multiple years)	15	19	35	25
Number of undergraduate students trained	14	14	38	40
Number of peer-reviewed publications	5	6	28	48
One collaborative peer-reviewed publication by each CSMS TC and/or PUI faculty	0	0	0 **(M3)**	6-8
Number of conference presentations by faculty (oral and poster)	25	9	31	40
Number of conference presentations by graduate students and postdocs (oral and poster)	23	5	89	63
Number of conference presentations by undergraduate students (oral and poster)	4	1	29	40
Percentage of all publications in high-impact journals	75%	75%	88%	25%
Number of cumulative citations	5	25	191	200
Number of invention disclosures submitted	5	5	3	10
Number of projects funded with private sector partners (includes SBIR/STTR)	1	2	1 **(M4)**	12
Funding for TC faculty to participate in the research centers *(ND has 5 TCs – efforts are currently underway, via campus visits to*	$84,991 Direct	$87,542 Direct	$90,168 Direct	$530,915 Total

learn which TC faculty members wish to work with the CRCS or CSMS as cluster members; funds represent total funding to TCs)				
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	$169,624 Direct	$531,000 Total

Mitigation Plans for CSMS Metrics that are currently listed as behind schedule:

- **M1:** (*Globus Online Implementation / HPC Equipment for CSMS activity*) Since these metrics were reported as behind schedule at the March 2016 NSF RSV, the new computational polymer faculty, Bakhtiyor Rasulev, Coatings and Polymeric Materials, NDSU, was hired in January 2017. He has already been tasked with moving this initiative forward. The computational faculty member will determine whether the Globus online implementation and HPC equipment are necessary to conduct CSMS research.
- **M2:** (*Number of new hires*) A candidate for the Life Cycle Assessment (LCA) faculty position declined our offer, so the search was restarted and a significant amount of networking was carried out with target research groups to attract candidates to apply for the position. Three candidates were selected for on-campus interviews which were completed March 31, 2017. The search committee has met and selected a candidate. Documentation to make an official offer is underway.
- **M3:** (*One collaborative peer-reviewed publication by each CSMS TC and/or PUI faculty*) Since this metric was reported as behind schedule at the March 2016 NSF RSV, CSMS participants at NDSU and UND have partnered with TC and PUI participants in ways that are producing results; as evidenced during the student poster session at ND EPSCoR's recent Annual State Conference. Also, there is at least one NDSU/PUI manuscript in progress. ND EPSCoR believes that this issue will soon begin to resolve itself, which is why we have recorded this metric as "on schedule" and will revisit it again prior to the NSF site visit in August 2017.
- **M4:** [*Number of projects funded with private sector partners (includes SBIR/STTR)]* Since this metric was reported as behind schedule at the March 2016 NSF RSV, CSMS participants have been talking to their industry collaborators. There are currently several project proposals on the drawing board, which is why ND EPSCoR has recorded this metric as "on schedule." We will revisit it again prior to the NSF site visit in August 2017.

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, **Chad Ulven** (Associate Professor, Mechanical Engineering, NDSU) served as the NATURE Sunday Academy Coordinator in Y1-3 and is a member of the CSMS group. The

Diversity co-Lead, **Scott Hanson (**ND EPSCoR Tribal Colleges Liaison) provides liaison expertise between NDSU, UND the TCs and the PUIs for all facets of the program.

Team Participants:

- **Julia Bowsher** (Associate Professor, Biological Sciences, NDSU) co-coordinates NATURE Sunday Academy beginning in Y4.
- **Ruth Buffalo (**American Indian STEM Mentor, NDSU) serves in that campus' NASSE position.
- **Tyson Jeannotte** (NASSE Mentor, UND) serves in that campus' NASSE position.
- **Barry Milavetz** (ND EPSCoR Associate Project Director) serves as a team/EPSCoR leadership facilitator for the team, specifically its UND members.
- **Britt Heidinger** (Assistant Professor, Biological Sciences, NDSU) co-coordinates NATURE Sunday Academy beginning in Y4.
- **Aaron Kennedy** (CRCS co-Lead) provides the Diversity leadership for CRCS.
- **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
- **David Roberts** (CRCS co-Lead) provides the Diversity leadership for CRCS.
- **Muk Sibi** (CSMS co-Lead) provides the Diversity leadership for CSMS.
- **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.
- **Dean Webster** (CSMS Lead) provides the Diversity leadership for CSMS.
- **Jianglong Zhang** (CRCS Lead) provides the Diversity leadership for CRCS.
- **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, who was then serving as ND EPSCoR's 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/Milavetz)**					
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/J. Zhang/Roberts/Kennedy/Webster/Sibi)**					
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. **(HansonPieri/J. Zhang/Roberts/Kennedy/WebsterSibi)**					
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. **(Hanson/Bowsher/Heidinger/ J. Zhang/Roberts/Kennedy/WebsterSibi)**					
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/ Jeannotte/Buffalo/Webster/Sibi/J. Zhang//Roberts/Kennedy)**					
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	Place Cohort #1 American Indian students in research groups. *Jeannotte hired at UND replaced Hoffmann.*	Assess the success rates of students in research groups. Initiate Cohort #2. *Buffalo hired at NDSU replaced Ostrom-Blonigen.*	Assess the success rates of students in research groups. Initiate Cohort #3.

		once they are identified.			

Objective 2.2: Assist American Indian students to pursue and eventually obtain PhDs in STEM programs while maintaining contact with TCs. **(Hanson/JeannotteBuffalo/Webster/Sibi/J. Zhang//Roberts/Kennedy)**					
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. *Jeannotte hired at UND; replaced Hoffmann.*	Ongoing. *Buffalo hired at NDSU; replaced Ostrom-Blonigen.*	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. **(Milavetz/Ostrom-Blonigen/ Webster/Sibi/J. Zhang//Roberts/Kennedy)**					
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. **(Hanson/Pieri/Bowsher/Heidinger/ Webster/Sibi/J. Zhang/Roberts/ Kennedy)**					
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)**	**Year 3 (through March 15, 2017)**	**Five-Year Cumulative Targets**
Hire Tribal Colleges Liaison	Hired	Continuing	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	$90,168 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	$169,624 Direct	$531,000 Total
Number of meetings of the EMPOWERED-ND Corps	N/A	5	7	At least every other month (in Y2-Y5 = 24)
Add UG researchers each year to the clusters identified through NATURE	N/A	3	5	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	UND: Hire made during Summer 2016 was retained	2 – ½ time **(M1)**
		NDSU: First meeting following holding pattern, pending reorganization of unit was	NDSU: First meeting on 8/26/16, but campus has not yet been able to hire an American Indian advisor	

		held on 8/26/16		
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	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*	7 participated in advanced track (NATURE+) of 2016 University Summer Camp *2017 Camp scheduled for 6/5-16/17*	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	2	5
Assist American Indian students in obtaining their doctorate degree: NATURE+	N/A	0	0	Metric expanded following NSF Site Visit to also include TC faculty: 5 **(M2)**
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	2	5
Assist American Indian students in obtaining their M.S. degree: NATURE+	N/A	0	3	5
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	0	Metric reduced following NSF Site Visit: 2 **(M3)**

Increase the number of newly promoted and/or tenured women faculty in STEM programs at NDSU and UND: WISE-related	N/A	12	10	2
Number of TC cluster faculty	6	5	7	2-3 per cluster
Number of cluster themes integrated with university summer camps: NATURE+	2	*Camp held June 6-17, 2016*	2 labs tour *at UND (both CRCS) during 2015 camp* 5 lab tours *1 lab tour at UND (CRCS) and 4 lab tours at NDSU (all CSMS) during 2016 camp* 3 research mentors *at NDSU (all CSMS) during 2016 camp* *2017 Camp scheduled for 6/5-16/17*	2-3
Number of cluster faculty/post-docs/GRA	3	5	9	2-3
Number of cluster themes integrated with Sunday Academy programs: NATURE+	2	3	2	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	60 women, 25 of whom are American Indian *(these counts are repetitive)*	10 women 10 American Indians
Number of American Indians involved in NATURE	N/A	N/A	268 *(these counts are repetitive)*	New Metric: Approved at 2016 RSV 10 American Indians
Award EPSCoR seed grants to women faculty: WISE-related	1 at NDSU	1 at NDSU	3 (to be awarded at UND)	8+

Mitigation Plans for Diversity Metrics that are currently listed as behind schedule:

- **M1:** (*Hire American Indian advisors with STEM backgrounds to advise American Indian students at NDSU*): Since this metric was reported as behind schedule at the March 2016 NSF RSV NDSU has not been successful in hiring a ½ time person; therefore, given that the award is at the halfway mark, NDSU will attempt to hire a full-time American Indian advisor before the end of Year 3 for the remainder of the award.
- **M2:** (*Assist American Indian students in obtaining their doctorate degree)* Since this metric was reported as behind schedule at the March 2016 NSF RSV, ND EPSCoR has made a concerted effort to visit with each of the American Indian students currently completing Master's degrees at NDSU and UND. As reported in the metric just before this one, 2 current M.S. students have already expressed interest in a STEM Ph.D. *However, based on the initiatives outlined in the Broader Impacts White Paper for TCs and PUIs, this metric will be reviewed with our NSF program director for possible expansion to TC faculty. This metric was expanded following NSF Site Visit to include TC faculty.* ***This metric was expanded to include TC faculty following NSF Site Visit.***
- **M3:** (*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*) Since this metric was reported as behind schedule at the March 2016 NSF RSV, the ND EPSCoR EMPOWERED-ND Corps has developed a *White Paper on Broader Impacts* at each TC and PUI. Although there are one or two success stories in the other graduate school recruitment metrics, it highly likely that the numbers associated with this particular initiative will not be reached during this award. *Based on the initiatives outlined in the Broader Impacts White Paper for TCs and PUIs, this metric will be reviewed with our NSF Program Director for possible adjustment.* ***This metric was reduced from 5 to 2 following NSF Site Visit.***

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, **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. The other team co-Lead, **Ashley Hutchison** Assistant Professor, Counseling studies the K-12 liaison to the CRCS and CSMS groups.

Team Participants:

- **Aaron Bergstrom** (High Performance Computing Specialist, Center for Computational Research, UND) serves as one the teams' two cyberinfrastructure experts.
- **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
- **Cindy Juntunen** (Dean and Professor, Counseling, UND) serves as a liaison/mentor to the K-12 education research and outreach team members.
- **Aaron Kennedy** (CRCS co-Lead) provides the Education and Workforce Development leadership for CRCS.
- **Barry Milavetz** (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.
- **Jean Ostrom-Blonigen** (ND EPSCoR Project Administrator, NDSU) serves as a team/EPSCoR leadership facilitator/liaison for the team, specifically its NDSU members.

- **David Roberts** (CRCS co-Lead) provides the Education and Workforce Development leadership for CRCS.
- **Mukund Sibi** (CSMS co-Lead and Distinguished Professor, CBC, NDSU) provides the Education and Workforce Development leadership for CSMS and serves as an education and workforce development research liaison from the CSMS group to the EMPOWERED-ND Corps.
- **Dane Skow** (Executive Director, Center for Computational Assisted Science & Technology, NDSU) serves as one of the teams' two cyberinfrastructure experts.
- **Ryan Summers** (Assistant Professor, Middle and Secondary Program Area Coordinator, Teaching and Learning, UND) develops lessons for K-12 students.
- **Timothy Young** (Professor, Physics and Astrophysics, UND) serves as an outreach liaison for K12 and the general public.
- **Dean Webster** (CSMS co-Lead) provides the Education and Workforce Development leadership for CSMS.
- **Jianglong Zhang** (CRCS Lead) provides the Education and Workforce Development leadership for CRCS.
- **Vacant** (ND EPSCoR STEM Manager). ND EPSCoR is currently screening for this new position.
- 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/Summers)**					
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/ Hutchison/Summers)**	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/Summers)**		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/Summers)**					
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/Summers)**	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/Summers)**	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/ Skow)**	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/ Skow)**	Hold CI sessions at statewide EPSCoR events.	Ongoing.	Ongoing.	Ongoing.	Ongoing.
General HPC information session for NATURE program. **(Bergstrom/ Skow)**	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/ Jeannotte/Buffalo)**	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. *Jeannotte hired at UND replaced Hoffmann.*	Ongoing. *Buffalo hired at NDSU replaced Ostrom-Blonigen*	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/Summers**)	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 Kennedy/Roberts)**	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/**	Articulate criteria for and recruit initial RPPAC. Identify list of PD seminars, semester projects for trainees and	Provide two seminars per semester. Communicate standards of mastery. Evaluate trainee writing/work.	Ongoing.	Ongoing.	Ongoing.

Sibi/ Kennedy/Roberts)	establish standards for performance.	Provide feedback to trainees.			
Develop and integrate Science Communication Projects into REU program. **(Nyachwaya/ Kennedy/Roberts/ 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/Summers)**	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/ Kennedy/Roberts/ 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/ Skow**)	Train graduate students.	Ongoing.	Ongoing.	Ongoing.	Ongoing.
Create a well-trained workforce in biomass-related STEM research. **(Webster/Sibi)**	N/A.	N/A.	N/A	Submit proposal for new interdiscliplinary course in Biopolymers and Biocomposites.	Teach new course in Biopolymers and Biocomposites.

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)**	**Y3 (through March 15, 2017)**	**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 *(one TC is not yet governed by an IRB/RRB); if that changes, we will also work with that campus)*	N/A	4	N/A	NEW Metric Approved at 2016 RSV: 4+
Obtain Institutional Review Boards approval from the 2 research universities to collect data during the NATURE Sunday Academy sessions	N/A	2	N/A	NEW Metric Approved at 2016 RSV: 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	 102 102 102	Change approved at 2016 RSV: 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	N/A	N/A	Change approved at 2016 RSV: .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	 102 102 102	Change approved at 2016 RSV: 300-450 **(M1)** 300-450 **(M1)** 300-450 **(M1)**
Number of 7th/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	 91 91 91	Change approved at 2016 RSV: 300-450 **(M1)** 300-450 **(M1)** 300-450 **(M1)**
Number of 4th/5th grade Rural students completing Post-Test Self-efficacy Interests & Values	 N/A N/A N/A	N/A N/A N/A	 NA N/A N/A	Change approved at 2016 RSV: 300-450 300-450

Major/Career Intentions/Goals (incl. repeated measures)				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	NA N/A N/A	Change approved at 2016 RSV: 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	N/A	Change approved at 2016 RSV: .25 SD increase
Number of mentor pairs (identified in year 2)	N/A	*0 – currently recruiting*	0	24 **(M2)**
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	N/A	.50 SD increase
Training of educators to initiate new classroom interventions	N/A	0	18	8-16
Number of CRCS and CSMS podcasts developed	N/A	0 – *Spring & Summer, 2016*	2 (in May 2017)	6-10
~~Number of high school students completing STEM Major/Career Intentions Scale, following podcast viewing~~ <u>Determine the impact of STEM modeling by trained teachers</u>	N/A	0 – *Spring & Summer, 2016*	0	Metric revised following NSF Site Visit: ~~600-900~~ Assess science interest among students in the classrooms of the teachers participating in the DSU Summer 2018 training **(M2)**
Number of ND undergraduates recruited as REU participants, 70% from TC/PUIs	N/A	5 *(80% were from TC/PUIs)*	0 *(planning to award 7 yet in Y3)*	12-15
Number of PUI/TC students recruited into Master's and Doctoral programs: NASSE	N/A	1	9	6
Number of Graduate Research Assistantships (GRA) and Doctoral Dissertation Assistantships (DDA)	N/A	1	19	6

awarded to STEM graduate students: NATURE+				
Number of seminars provided both in-person and over the web	N/A	CRCS – 8 CSMS – 20	CRCS: -1 CSMS: -13 *(there are a total of 14 RPPAC seminars to date)* **(M3)**	Metric reduced following NSF Site Visit:35
NEW: Number of students attending seminars	N/A	N/A	N/A	81
Number of summer seminar series provided in-person or via web	N/A	0; *Summer 2016*	10	4
Number of REU participant-generated science communication project created and disseminated via WWW	N/A	0; *Summer 2016*	1 REU webinet *(2 podcasts in May 2017)*	4-8
Number of electronic outreach portfolios available on cluster websites	N/A	0 – CRCS 0 – CSMS *Summer 2016*	3 CSMS *(Sunday Academy, University Camp, outreach to 2 students from SBC)*	6
Number of graduate students participating in HPC Bootcamps	9	0; *Spring & Summer 2016*	0 *(lost HPC Director at NDSU, filed mitigation plan with NSF that slightly delays this metric)*	20
Number of informational meetings at TCs	6	9	5	5
Number of cluster researchers identified at TCs	6	5	7	>=5
Number of cluster researchers identified at PUIs through collaborative seed grants	N/A	7	7 *(3 at DSU, 1 at MaSU, 1 at MiSU, 2 at VCSU)*	>=4
Number of HPC Bootcamps for faculty, staff and students at all locations	2	0; *Scheduled 1 Spring, 1 Summer 2016*	2 1 *online bootcamp in April/May 2016 to VCSU (8 hours over a two*	9

			week period) *AND* *1 HPC tour at NDSU during April 2017 conference (lost HPC Director, filed mitigation plan with NSF that slightly delays this metric)*	
Number of TC/PUI participants in cluster group meetings	CRCS – 3 CSMS – 4	CRCS – 6 CSMS – 3	CRCS: 5 CSMS: 7	45
Number of TC/PUI faculty attendees at state conference	4	N/A; *April 2016*	6 (April 2016) 11 (April 2017)	45
Number of cluster-related conference presentations including TC/PUI authors	N/A	CRCS – 3 CSMS – 0	CRCS: 2 CSMS: 10	17
Number of cluster-related publications including TC/PUI authors	N/A	CRCS – 7 CSMS – 0	CRCS: 9 CSMS: 0	9
Number of cluster-related proposals submitted including TC/PUI co-investigators	N/A	CRCS – 0 CSMS – 0	CRCS: 0 CSMS: 3 **(M4)**	15
Number of CI Sessions at state-wide EPSCoR Events	1 *(April 2015)*	0	1 (*April 2017)*	5
Number of activity ideas included in outreach portfolio	N/A	CRCS – 5 CSMS – 17	CRCS: 9 CSMS: 82	50-150
Number of outreach activities completed	CRCS – 2 CSMS – 2	CRCS – 2 CSMS – 0	CRCS: 35 CSMS: 79	50-200
Number of CRCS and CSMS apps developed for K-12	CRCS – 1 CSMS – 0	CRCS – 0 CSMS – 0	CRCS: 0 CSMS: 0	1
Number of CRCS and CSMS lesson plans in classrooms	N/A	CRCS – 0 CSMS – 0	CRCS: 0 CSMS: 0	30

Number of general HPC information sessions for NATURE program	1	0	0 *(1 planned for Summer 2017)*	5-10
NEW: Number of students enrolled in course on Biopolymers and Biocomposites (Fall 2018)	N/A	N/A	N/A	10

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

Mitigation Plans for Education and Workforce Development Metrics that are currently listed as behind schedule:

- **M1:** [*Number of mentor pairs (identified in year 2*)] The team has been unsuccessful in meeting this metric. Our next approach will be to reach out to NATURE SA completers and 8th grade RK12O participants, and match them with REU and other undergraduate students in the CRCS and CSMS clusters. Also, as discussed in the narrative, a variety of new strategies for energizing the mentorship activity have been identified and will be tried.
- **M2:** (*Number of high school students completing STEM Major/Career Intentions Scale, following podcast viewing*) Progress on this metric was impeded by the delays in podcasts being produced by CRCS and CSMS and by the REU participants. During Year 3, the metrics for the podcasts moved from "behind schedule" to "on schedule." ***This metric was replaced following the NSF Site Visit by a new metric: Determine the impact of STEM modeling by trained teachers.***
- **M3**: (*Number of seminars provided both in-person and over the web*) Since this metric was reported as behind schedule at the March 2016 NSF RSV, our Year 3 metric audit showed that CRCS and CSMS had both over-reported this metric. However, this metric was not originally interpreted as RPPAC seminars with ND EPSCoR student participants. ND EPSCoR is clarifying this interpretation in this manner because the shift away from postdoctoral research participants to undergraduate and graduate research participants makes these training sessions essential to the success of the project. *This metric will be reviewed with our NSF Program Director to determine if ND EPSCoR can change it to a two-part metric that captures both the number of seminars and the number of student attendees. Additionally, during Year 4, ND EPSCoR will explore the possibility of recording these sessions for later viewing by students who are not able to attend.* ***The metric related to the number of seminars was reduced from 81 to 35 following the NSF Site Visit. Additionally, a second metric to track the number of students attending these seminars in Y4 and Y5 was added***
- **M4:** (*Number of cluster-related proposals submitted including TC/PUI co-investigators*) Since this metric was reported as behind schedule at the March 2016 NSF RSV, our RU participants have partnered with TC and PUI participants in ways that are producing results; as evidenced during the student poster session at ND EPSCoR's recent Annual State Conference. ND EPSCoR believes that this issue will soon begin to resolve itself, which is why we have recorded this metric as "on schedule." We will revisit it again prior to the NSF site visit in August 2017.

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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: Mukund Sibi (CSMS co-Lead and Distinguished Professor, Chemistry and Biochemistry, NDSU) and **Michael Moore** (Associate Vice President for Corporate Engagement and Commercialization, UND, are 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.
- **Frank Bowman** (Associate Professor, Chemical Engineering, UND) serves as a liaison from the CRCS group.
- **Anne Denton** (Associate Professor, Computer Science, NDSU) serves as a liaison from the CRCS group.
- **Joyce Eisenbraun** (ND EPSCoR Communications Manager) serves as the communications liaison to the ND EPSCoR State Office.

- **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) provides liaison expertise between ND EPSCoR, the TCs, and the EMPOWERED-ND Corps for all facets of the program.
- **Aaron Kennedy** (CRCS co-Lead) provides the Partnerships, Collaborations and Communication leadership for CRCS.
- **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.
- **Barry Milavetz** (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.
- **Jean Ostrom-Blonigen** (ND EPSCoR Project Administrator, NDSU) serves as a team/EPSCoR leadership liaison for the team, specifically its NDSU members.
- **David Roberts** (CRCS co-Lead) provides the Partnerships, Collaborations and Communication leadership for CRCS.
- **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 Lead) provides the Partnerships, Collaborations and Communication leadership for CSMS.
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- **Jianglong Zhang** (CRCS Lead) provides the Partnerships, Collaborations and Communication leadership for CRCS.
- 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.
Translate one or more CSMS laboratory findings to commercial products that have societal impact.	N/A.	N/A.	N/A.	Issue call for proposals for translational seed grant awards. Fund at least three projects.	Projects are completed.
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/J. Zhang/Roberts/Kennedy/Moore)**					
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/Moore/ Webster/J. Zhang/Roberts/ Kennedy Alberts/Majdik/Wahlberg/Rusch/ Milavetz/Ostrom-Blonigen/Hanson/Eisenbraun/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/Moore/ Webster/J. Zhang/Roberts/Kennedy/Hutchison/Nyachawaya/ Alberts/Majdik/ Rusch/ Milavetz/ Ostrom-Blonigen/Hanson/Eisenbraun/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/Milavetz/Ostrom-Blonigen/Eisenbraun)**					
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/Moore/ Webster/J. Zhang/Roberts/Kennedy Alberts/Majdik/Wahlberg/ Rusch/Milavetz/Ostrom-Blonigen/Hanson/Eisenbraun/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/Milavetz/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)**	**Y3 (through March 15, 2017)**	**Five-Year Cumulative Targets**
Number of Research ND proposals submitted	N/A	1	0	4
Number of translation research initiatives at $10,000 each	N/A	CRCS – 3 CSMS – 2	CRCS : 0 CSMS : 0	6
Number of SBIR/STTR proposals submitted	N/A	CRCS – N/A CSMS – 3	0	4
NEW: Translational seed grant awards that result in a collaboration agreement or license/option with industrial partner	N/A	N/A	0	2
Number of climate data partners	N/A	CRCS – 1 CSMS – N/A	2	5
Number of ~~DoE and USDA~~ National Lab partners	N/A	CRCS – N/A CSMS – 1	3* **(M1)**	10
Number of ~~DoE~~ National Lab student internships	N/A	CRCS – N/A CSMS – 0	1** **(M2)**	5
Number of agricultural group partners	N/A	CRCS – 3 CSMS – N/A	3	12
Number of ND industry partners	N/A	CRCS – 2 CSMS – 3	CRCS: -1 CSMS: -1 ND EPSCoR: 15 **(M3)**	8
Number of student interns (ND)	N/A	CRCS – 0 CSMS – 1	CRCS: 0 CSMS: 1 ND EPSCoR: 30 **(M3)**	13
Number of regional industry partners	N/A	CRCS – 1 CSMS – 0	CRCS: 0 CSMS: 4	5
Number of student interns (regional)	N/A	CRCS – 0 CSMS – 0	CRCS: 2 CSMS: 0	6

% New content added to website	CRCS – 100% CSMS – N/A ND EPSCoR – N/A	CRCS – 20% CSMS – 100% ND EPSCoR – *Y2 go live*	CRCS: 70% CSMS: 58.2% ND EPSCoR: Live, August 2016; 100%	Base +75%
~~Number of visits to website~~	~~N/A~~	~~*CRCS – 1799 CSMS – 414 ND EPSCoR – Y2 go live*~~	~~*CRCS: 1,680 CSMS: 4,392 ND EPSCoR: N/A – ND university system web software does not count visits*~~ ***(M4)***	Metric eliminated following NSF Site Visit: ~~4400~~
Number of news items posted to the website	CRCS – 0 CSMS – N/A	CRCS – 0 CSMS – 10	CRCS: 13 CSMS: -1 **(M5)**	47
Number of blog entries	N/A	CRCS – 0 CSMS – 2	CRCS: 3 CSMS: 9	22
Number of media outlet reports	N/A	CRCS – 0 CSMS – 2	CRCS: 4 CSMS: 85	23
Number of in-house seminar series	N/A	CRCS – 1 CSMS – 1	CRCS: 1 CSMS: 1	4+
Number of Science Café events	CRCS – 1 CSMS – N/A	CRCS – 0 CSMS – 0	CRCS: 3 CSMS: 0	8
New content added to CRCS & CSMS websites	N/A	CRCS – 15 CSMS – 84	CRCS: 85 CSMS: 20	175
Number of visits to websites	N/A	CRCS – 1799 CSMS – 414	CRCS: 1,680 CSMS: 4,392	2200

Number of EMPOWERED-ND publicity items (e.g.: video, blogs, print)	N/A	6	25	36
Annual Report published	1 *(May 2015)*	0	1 *(May 2016)* *May 2017 pending*	5
Number of TC/PUI visits	CRCS – 5 CSMS – 3 TC Liaison Manager – 5	CRCS – 0 CSMS – 2 TC Liaison Manager – 5	CRCS: 3 CSMS: 0 TC Liaison Manager: 8 *PD/Assoc. PD/PA:* 9	10
Number of legislator visits	1	1	1 *(Four ND Legislators attended the 11/2015 EPSCoR National Conference)* 1 *(individual meeting with a ND Senator at UND)* 1 *(ND Legislative Committee on Higher Education at NDSU, 2/2016)*	9
Number of campus open forums	N/A	CRCS – 0 CSMS – 1	CRCS: 3 CSMS: 1	9
Number of community/school/industry group visits	N/A	CRCS – 1 CSMS – 2	CRCS: 5 CSMS: 1	7
Annual conference held	1	0	1 *(4/2016)* 1 *(4/2017)*	5
Number of external advisory board meetings	1 *(4/2015)*	1 *(11/2015)*	1 *(4/2016)* 1 *(10/2016)* 1 *(4/2017)*	5

Mitigation Plans for Partnership, Collaborations and Communication Metrics that are currently listed as behind schedule:

- **M1:** (*Number of DoE and USDA Lab partners*) Since this metric was reported as behind schedule at the March 2016 NSF RSV, one more USDA partnership was initiated. Also included in this number are two additional national laboratory partnerships (Pacific Northwestern National Laboratory and United States Army Research Laboratory). ***To increase ND EPSCoR's ability to meet the intent of this metric, ND EPSCoR will request NSF approval to expand this metric to all national laboratories beyond DoE and USDA. **This metric was expanded to include all national laboratories following the NSF Site Visit.***
- **M2**: (*Number of DoE Lab student internships*) Since this metric was reported as behind schedule at the March 2016 NSF RSV, one CSMS graduate student (Kyle Kingsley) received training at the UDSA Agricultural Research Service; although not a formal internship with DoE, it is counted here. *** To increase ND EPSCoR's ability to meet the intent of this metric, ND EPSCoR will request NSF approval to expand this metric to include training and internships at all national laboratories including DoE. **This metric was expanded to include all national laboratories following the NSF Site Visit.***
- **M3:** [*Number of ND industry partners / Number of student interns (ND)]* Our Year 3 metric audit showed that CRCS over-reported its ND industry partners in Year 2 by 1 and that the STTAR student intern for one ND CSMS industry partner backed out. Through the ND EPSCoR STTAR program, ND companies that employ RU, TC or PUI students are eligible to receive partial reimbursement of the student's wages. The ND EPSCoR numbers reported in Year 3 represent the number of unique ND industries and unique student interns who participated in the ND EPSCoR STTAR program since the beginning of the award.
- **M4:** *[Number of visits to website (includes ND EPSCoR)*] since ND EPSCoR's website is a "child" of a ND University System website, it does not count visitors; they are counted at the "parent" site. Thus, this metric is now redundant of another metric in this section [*Number of visits to websites (CRCS and CSMS sites only)*]. *ND EPSCoR will request NSF approval to eliminate this metric from our reporting requirements. **This metric was eliminated following the NSF Site Visit.***
- **M5:** (*Number of news items posted to the website*) Following the changes made by our new Communicating Science senior personnel related to what is a news item, a blog item or a media outlet report, our Year 3 metric audit showed that this CSMS count is now over-reported by 1.

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: Dane Skow (Executive 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.

Integrated Cyberinfrastructure Activities:

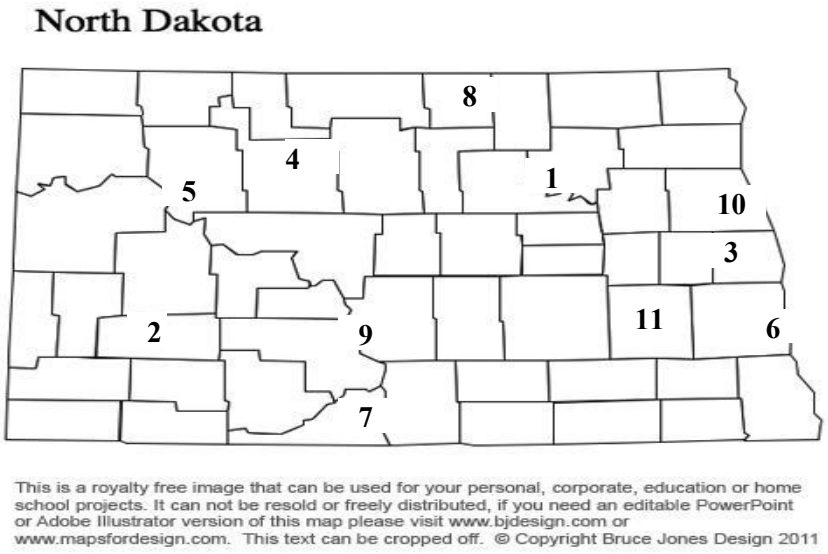
1. Develop an efficient implementation of the Globus Online GridFTP data transfer tool (*Focus Area 1, Goal 2, Objective 2.2 and Focus Area 2, Goal 2, Objective 2.5*).
2. Architect and build local Relational Database Management system (RDBMS) minicloud at NDSU in support of collaborative activities within 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, Milavetz, Ostrom-Blonigen

ND EPSCoR State Office: administered by North Dakota State University (NDSU) in Fargo, ND under a memorandum of understanding with the ND University System. Kelly Rusch, the NDSU vice president for research and creative activity serves as the ND EPSCoR State Executive Director. Richard Rothaus, the ND University Vice Chancellor for Academic and Student Affairs chairs the ND EPSCoR Steering Committee. ND EPSCoR leadership staff are also located at both UND (Co-PI: Barry Milavetz, associate vice president for economic development) and NDSU (Co-PI: Jean Ostrom-Blonigen, ND EPSCoR project administrator).

Management Structure: The ND EPSCoR State Executive Director (Rusch), Associate Director (vacant), Project Administrator (Ostrom-Blonigen) and the ND EPSCoR State Office team (Slicer, Hanson, Eisenbraun and Wahlberg) will oversee the implementation of INSPIRE-ND. They will work with the sub-awardee PIs and the INSPIRE-ND Focus Area Leads to ensure timely execution of project components and delivery of outcomes. The ND EPSCoR Office Team coordinates project management, data gathering for reports, global event planning. The Focus Area Leads 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 ND University System chancellor 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
4.8 October 20, 2017 - NSF Site Visit recommendations
4.9 November 17, 2017 - ND EPSCoR's response to Site Visit recommendations
4.10 December 5, 2017 - NSF acceptance of ND EPSCoR Site Visit response #3 and #5 and request for additional information related to #1, #2 and #4
4.11 January 11, 2018 - Additional ND EPSCoR's Response to Site Visit recommendations #1, #2, and #4

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]
***[1/11/2018 Update: These positions have been filled.]

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 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.]

Bakhtiyor Rasulev started his appointment with the NDSU Department of Coatings and Polymeric Materials on January 3, 2017. He has a Ph.D. from the Institute of Bioorganic Chemistry, Uzpekistan and has had extensive postdoctoral experience at Jackson State University and at the NDSU Center for Computationally Assisted Science and Technology.

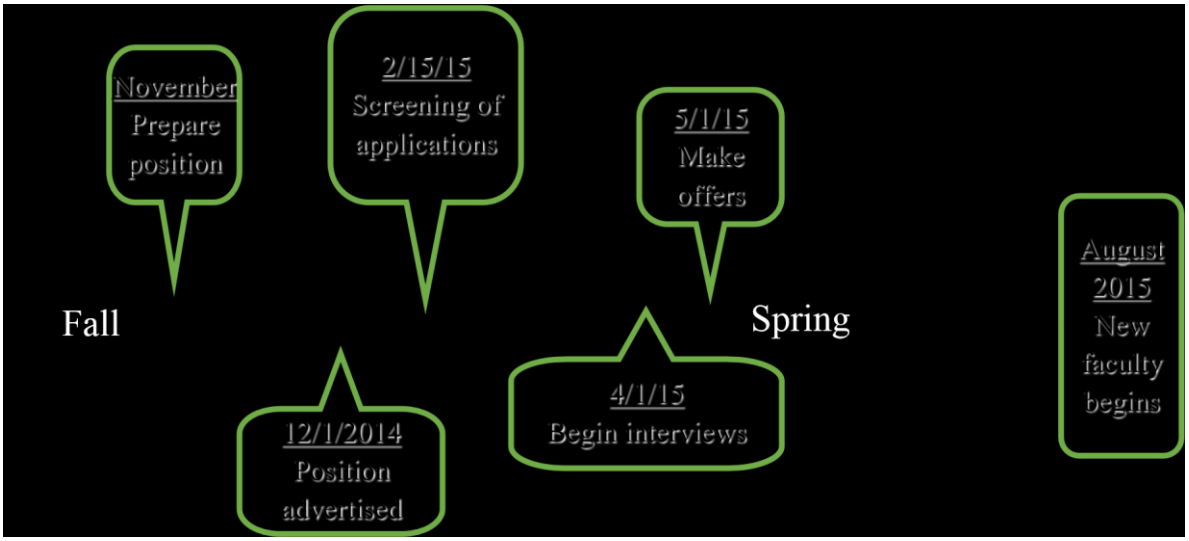
Ghasideh Pourhashem started her appointment with the NDSU Department of Coatings and Polymeric Materials on November 15, 2017. She has a Ph.D. from Drexel University and has postdoctoral experience at Rice University.

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.