Envisioning the Future of NSF EPSCoR

COMMITTEE ON THE FUTURE OF NSF EPSCoR

FINAL REPORT

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1. ACKNOWLEDGEMENTS

SUBCOMMITTEE MEMBERSHIP

Prabhakar Clement
Director
Center for Water Quality Research
Professor of Environmental Engineering
The University of Alabama

Edwin Cruz-Rivera
Associate Professor
Department of Biological Sciences
University of the Virgin Islands

Christine Cutucache
Director
STEM TRAIL Center
Haddix Community Chair of Science
Associate Professor of Biology
University of Nebraska at Omaha

Mary Jo Daniel
Associate Vice President for Research
University of New Mexico

Jose D. Fuentes
Co-Chair, Subcommittee
Professor of Meteorology
Department of Meteorology and
Atmospheric Science
The Pennsylvania State University

Michael Khonsari
Dow Chemical Endowed Chair
Professor
Louisiana State University

Daniela Marghitu
Faculty Coordinator and Director
Research Laboratory for Education and
Assistive Technology
Computer Science and Software Engineering
Department
Samuel Ginn College of Engineering
Auburn University

Marian G. McCord
Senior Vice Provost for Research, Economic
Engagement, and Outreach
University of New Hampshire

Julia Melkers
Professor
School of Public Policy
Georgia Institute of Technology

Sheena Murphy
Associate Vice President for Research
Development
Professor of Physics
West Virginia University

Prakash Nagarkatti
Senior Research Advisor to the President
Carolina Distinguished Professor
University of South Carolina

Kathie L. Olsen
Founder
KLO International, LLC
Former Deputy Director and Chief Operating
Officer
National Science Foundation

James Rattling Leaf
Research Associate
Cooperative Institute for Research in
Environmental Sciences
University of Colorado-Boulder

Susan Renoe
Associate Vice Chancellor for Research,
Extension & Engagement
University of Missouri

Manuel Rodriguez-Martinez
Professor
Department of Computer Science and
Engineering
University of Puerto Rico, Mayaguez

Kelly A. Rusch
Co-chair, Subcommittee
Executive Director
North Dakota EPSCoR
Associate Chair and Professor
Department of Civil, Construction and
Environmental Engineering
North Dakota State University

Carol L. Silva
Co-Director
National Institute for Risk and Resilience
Director
Center for Risk and Crisis Management
Edith Kinney Gaylord Presidential Professor
of Political Science
University of Oklahoma

Scott A. Wicker
Interim Chair
Associate Professor of Chemistry
School of Science, Technology, Engineering,
and Mathematics (SoSTEM)
College of Agriculture, Communities, and
Sciences
Kentucky State University
Jefferson Science Fellow
National Academy of Sciences (NAS)
Leadership Fellow
Center for Advancement of STEM Leadership

NSF STAFF

Alicia J. Knoelder
Office Head
Office of Integrative Activities

Sandra Richardson
EPSCoR Section Head
Office of Integrative Activities

Loretta A. Moore
Former EPSCoR Section Head
Office of Integrative Activities

Timothy M. VanReken
Program Director
Office of Integrative Activities

Bernice T. Anderson
Senior Advisor
Office of Integrative Activities

Robyn D. McRey
Contracting Officer's Representative
Office of Integrative Activities

Elizabeth Lawrence
Senior Program Analyst
Office of Integrative Activities

Kevin C. Cooke
The American Association for Advancement
of Science (AAAS) Science and Technology
Policy Fellow
Office of Integrative Activities

Una Alford
Program Analyst
Office of Integrative Activities

Tracy Shields
Program Analyst
Office of Integrative Activities

Thomas J. Jones
Staff Associate for Budget
Office of Integrative Activities

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2. ABBREVIATIONS AND ACRONYMS

2D: Two-dimensional

AI/AN: American Indian/Alaska Native

AISES: American Indian Science and Engineering Society

BESW: Building Excellence in STEM Workforce Initiative

BREE: Basin Resilience to Extreme Events

CARES Act: Coronavirus Aid, Relief, and Economic Security Act

CEMOS: Center for Emergent Molecular Optoelectronics

CEOSE: Committee on Equal Opportunities in Science and Engineering

CIRCLES: Cultivating Indigenous Research Communities for Leadership in Education and STEM

COBRE: Centers of Biomedical Research Excellence

COV: Committee of Visitors

CWDD: Center for Workforce Development and Diversity

DCL: Dear Colleague Letter

DFMs: Distribution Feeder Microgrids

DOC: Department of Commerce

EDA: Economic Development Administration

EDC: Economic Development Council

EPSCoR: Established Program to Stimulate Competitive Research

ERC: Engineering Research Center

ESA: Ecological Society of America

FIRST: Faculty Institutional Recruitment for Sustainable Transformation

FY: Fiscal Year

GEM3: Genes by Environment

GOALI: Grant Opportunities for Academic Liaison with Industry

GDP: Gross Domestic Product

HBCUs: Historically Black Colleges and Universities

HERS: Haskell Environmental Research Study Institute

HSIs: Hispanic-Serving Institutions

ICOR: Incentivizing Collaboration and Open Research

INCLUDES: Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science

IDA: Institute for Defense Analyses

LAMDA: Louisiana Materials Design Alliance

LGBTQ+: Lesbian, Gay, Bisexual, Transexual and Questioning and or other categories used to describe gender identities

MADE in SC: Materials Assembly and Design Excellence in South Carolina

MSIs: Minority-Serving Institutions

NASEM: National Academy of Sciences, Engineering, and Medicine

NCSES: National Center for Science and Engineering Statistics

NH Bio-Made: New Hampshire Center for Multiscale Modeling and Manufacturing of Biomaterials

NIH: National Institutes of Health

IDeA COBRE: National Institutes of Health Institutional Development Award Centers of Biomedical Research Excellence

NSB: National Science Board

NRT: NSF Research Traineeship

NSF: National Science Foundation

PI: Principal Investigator

PTMT: Patent Technology Monitoring Team

PUIs: Primarily Undergraduate Institutions

R&D: Research and Development

R&E: Research and Engineering

R1: Universities with High Research Activity

REU: Research Experience for Undergraduates

RFSSP: Research Faculty Start-up Support Program

RII: Research Infrastructure Improvement

S&E: Science and Engineering

S&T: Science and Technology

SACNAS: Society for Advancing Chicanos and Native Americans in Science

SBIR: Small Business Innovation Research

sEMG: Surface electromyography

SIS: Success In STEM

SMART: Sustainable, Modular, Adaptive, Resilient, and Transactive

STC: Science Technology Center

STEM: Science, Technology, Engineering and Mathematics

STPI: Science and Technology Policy Institute

STTR: Small Business Technology Transfer

TCUs: Tribal Colleges and Universities

TYCs: Two-Year Colleges

USPTO: United States Patent and Trademark Office

VPRS: Velocity Prediction Rating System

3. EXECUTIVE SUMMARY

The National Science Foundation Established Program to Stimulate Competitive Research (NSF EPSCoR) is designed to enhance the research competitiveness of targeted jurisdictions (states, territories, and commonwealths) by strengthening capacity and capability in science, technology, engineering, and mathematics (STEM). Establishing strong STEM training is critical for building the technology-based economy of the United States. Therefore, in March of 2021, NSF established a subcommittee on the Future of NSF EPSCoR to guide the visioning process and provide an opportunity for NSF EPSCoR and its stakeholders to collaboratively assess the effectiveness of the program and make recommendations to improve the program. The subcommittee's work and its engagements with the broader NSF EPSCoR stakeholder community are organized around two major motivating questions:

1. What does the available evidence tell us about the effectiveness of NSF EPSCoR's current investment strategies (both individually and collectively) in advancing scalable, jurisdiction-wide solutions and best practices to achieve the program's goals?

2. Based on the answers to the above, are there novel strategies or changes to the current strategies that would enable NSF EPSCoR and its jurisdictional partners to achieve its mission more effectively?

The subcommittee collected data from written comments and listening sessions from September to October 2021 and established four working groups to process the data and write a report focusing on four key areas related to the goals of the EPSCoR program: a) Research and Infrastructure Capacity and Competitiveness; b) Education and Workforce Development; c) Broadening Participation; and d) Economic Development. This report summarizes the data collected during the visioning process and offers recommendations and suggestions on ways to achieve further progress in meeting the goals of the program.

FINDINGS AND RECOMMENDATIONS

In Fiscal Year (FY) 2020, NSF EPSCoR invested $191.57 million in support of the program's activities. Evidence from the data collected through subcommittee activities and a review of extant reports on the program indicate that NSF EPSCoR has facilitated collaborations in areas of high national and NSF STEM priority areas, which has helped increase NSF funding to institutions participating in the program, increased the number of faculty hired and retained in NSF EPSCoR jurisdictions, and supported research infrastructure and Science and Engineering (S&E) education programs. Although these data provide evidence for the successes NSF EPSCoR has made toward meeting its programmatic goals, there is still progress to be made. The subcommittee strongly agrees that NSF EPSCoR jurisdictions can serve as a lever of American innovation and, therefore, further expand research and development if adequately scaled,

resourced, and coupled with capacity-building programs that promote longer-term research success at every level. To bolster and expand these efforts, the subcommittee has identified eight recommendations that address eight distinct needs. Common across these recommendations are three broad foci:

1. Expanding and Supporting Human Capital;
2. Bridge-Building;
3. Strengthening Resources and Infrastructure, with inclusion and diversity undergirding these three main areas.

The subcommittee's main recommendations are labeled with a prefix of the letter R, and additional suggestions are marked with a prefix of the letter S.

ECONOMIC DEVELOPMENT

Stakeholders discussed how NSF EPSCoR has stimulated economic development through job creation resulting from partnerships between the private sector and faculty, national laboratories supporting small businesses, the promotion of STEM through partnerships with informal science organizations, NSF EPSCoR supported startups, seed grant funding, and commercial applications. Stakeholders also identified a need for NSF funding strategies that link NSF EPSCoR to existing NSF programs that support small businesses, offer incentives to the private sector to partner with NSF EPSCoR institutions, and invest in startup companies through NSF EPSCoR's Research Infrastructure Improvement Track-1 program. To further increase the impact of the program on economic development within and across jurisdictions, the subcommittee recommends:

Image 1. Rifat-E-Nur Hossain, a Ph. D. student at Louisiana Tech University and Louisiana Materials Design Alliance (LAMDA) research, prepares a thermal camera for image capture during operation of a 3D printer. Source: Louisiana Tech University.

R1.   Ecosystem Approach to Investments: NSF should partner with other federal agencies to create new programs for coordinated and long-term strategic investment that will ensure capacity and support from the basic science questions through commercialization, job creation, and workforce support, while also expanding and using the internal EPSCoR co-funding mechanism and considering programs to encourage collaboration between NSF EPSCoR and non-NSF EPSCoR jurisdictions.

R2.   Increased Integration of NSF EPSCoR: NSF should adopt a more holistic view of NSF EPSCoR with a greater integration of NSF EPSCoR across the Foundation and more cross-fertilization between the NSF EPSCoR Section and the breadth of directorates within the Foundation and focus on developing internal programs that are more inclusive of the strengths and scientific priorities of NSF EPSCoR jurisdictions.

RESEARCH AND INFRASTRUCTURE CAPACITY AND COMPETITIVENESS

The subcommittee noted clear agreement among NSF EPSCoR stakeholders that the current program has significantly helped jurisdictions improve and enhance research capacity and competitiveness. However, listening session participants and stakeholders who submitted public comments identified the need for:

- greater investment in recruitment, retention, and training of faculty, researchers, and graduate students;
- investment in both the acquisition and maintenance of equipment and facilities;
- flexible identification of projects related to jurisdictional needs; and
- expanded investment in more projects and for longer periods.

To address these needs and further grow research capacity and infrastructure in NSF EPSCoR jurisdictions, the subcommittee recommends:

R3. **Diverse Talent Recruitment and Retention:** NSF should expand investments to grow the critical mass of highly competitive and capable faculty, technical staff, and students in NSF EPSCoR jurisdictions and develop new grant programs that will help build nationally competitive, sustainable research, and promote collaborations within and across NSF EPSCoR jurisdictions and beyond.

R4. **Physical and Administrative Infrastructure:** NSF should invest in physical and administrative infrastructure in EPSCoR jurisdictions that support research and economic development. This includes construction or modernization of research facilities and infrastructure, research instrumentation, and staff to support intellectual property development, commercialization, and corporate engagement—all of which are essential for building the research infrastructure for sustainable research and economic competitiveness in NSF EPSCoR jurisdictions.

EDUCATION AND WORKFORCE DEVELOPMENT

Stakeholders reported that NSF EPSCoR provides career development opportunities and builds STEM capabilities through collaboration opportunities, shared use of facilities, and support of undergraduate students, graduate students, and post-doctoral fellows. At the same time, stakeholders identified the need for greater investments in skillset development, such as management and leadership training for NSF

Image 2. The 2019 Cohort of the Haskell Environmental Research Studies Institute. Source: Jay T. Johnson, University of Kansas.

EPSCoR participants. Stakeholders also emphasized the need to support faculty release time, networking opportunities, education and research opportunities for students, and a greater engagement and exchange with the private sector to grow opportunities in education and workforce development. To address these education and workforce development needs, the subcommittee recommends:

R5. **Programs to Promote Intra- and Inter-jurisdictional Research, Education, and Workforce Development:** NSF should explore opportunities to fund collaborative proposals across multiple jurisdictions. Interjurisdictional opportunities could support topics of shared interest that are identified by the proposing project team that would leverage existing expertise and resources with the goal of promoting synergistic research, workforce development, and educational activities that can broaden impacts well beyond what single jurisdictions (particularly smaller ones) can accomplish. Providing such opportunities for collaboration also enables brain circulation and network development across multiple jurisdictions. Large intra- and inter-jurisdictional grants could have provisions to enable funding requests for the recruitment and retention of young faculty, thereby building a sustainable workforce.

R6. **Support for Workforce, Including Those with Diverse Career Pathways:** NSF should expand research and collaboration opportunities and related career support and mentoring for individuals at different career stages and pathways within NSF EPSCoR funding programs. EPSCoR projects provide rich and often unique opportunities for early career researchers that can be instrumental in their career advancement, for both academic and other broad career paths. Similarly, mid-career researchers can experience significant advantages in research leadership and advanced publication and grant opportunities that matter for promotion and professional recognition, particularly among underrepresented groups. Specific attention to these two critical career stages would create a deliberate and parallel effort to other NSF programs that prioritize opportunities for pre-tenure as well as pre-promotion mid-career faculty.

BROADENING PARTICIPATION

The listening sessions highlighted NSF EPSCoR's support for diversity and inclusion among faculty, students, and research communities. These stakeholders also thought there is a greater need to support Minority-Serving Institutions (MSIs) and Primarily Undergraduate Institutions (PUIs) through a separate Research Infrastructure Improvement (RII) track that would provide more support to PUI and MSI partners, fund release time for faculty, and fund workshops that support collaboration around shared issues and potential partnerships. Additionally, stakeholders identified the need for funding of research professorships for members of underrepresented groups to increase faculty diversity and quality in all stages of STEM research. Recognizing broadening participation of diverse groups and institutions in STEM as a key strategic goal of the program, the subcommittee recommends:

Image 3. This photo was taken by Don James and was submitted to NSF in 2017 as part of the Energize New Mexico Track-1 Award Annual Report. The New Mexico EPSCoR is a multi–faceted program aimed at improving the research, cyberinfrastructure, and human resources required for New Mexico to achieve its energy, education, and workforce development potential. Source: New Mexico EPSCoR.

R7. **Proactive Inclusion Strategies:** NSF should be accountable for the formation of diverse teams of researchers via partnerships between EPSCoR jurisdictions and researchers from underrepresented groups in all pre- and post-award facets of the NSF EPSCoR program, such as inclusion in panels, committees, commissions, and review boards. NSF EPSCoR researchers, especially those from underrepresented groups, need greater inclusion on NSF panels and advisory committees.

R8. **Access and Opportunity:** NSF should enhance geographic diversity by providing greater infrastructure support for Tribal Colleges and Universities (TCUs), Historically Black Colleges and Universities (HBCUs), Hispanic-Serving Institutions (HSIs), and other MSIs and PUIs, including Two-Year Colleges (TYCs), to engage in research efforts and enhance collaborations with external partners. Support must also include technical assistance to address gaps in research administration, funding of brick-and-mortar research facilities, institutional and interinstitutional research collaborations, and establishment of innovative mentoring

partnerships. In addition to providing support, EPSCoR must shift to tracking impactful outcomes to inform subsequent support.

Additionally, the subcommittee offers nineteen suggestions below that would strengthen the program.

Table 1. NSF EPSCoR Suggestions

Economic Development
S1. *Create innovation ecosystems through enhanced investment in physical and human capacity*, namely: resource research teams, research administration, technology transfer offices, collaborations, state economic development agencies, and industry partnership opportunities to enable synergistic ecosystems to develop, support, and retain talent, and to identify shared resources for continued innovation; invest in brick-and-mortar innovation hubs to be co-located with universities. This investment can support a robust research infrastructure with broadband, cybersecurity, and technology support, as well as an effective knowledge base with opportunities for partnerships to diversify and expand the reach of funding opportunities needed for sustainability. The innovations ecosystems-approach can also foster the expansion of infrastructure and new business formation, such as university-affiliated start-ups and memorandums of understanding with key entities in the private sector to ensure translation of the work more broadly. Finally, it may support regional economic gains that are recognized nationally and internationally.
S2. *Designate funds and/or scholarships for students and faculty to receive co-mentorship from industry and universities.* This would include Grant Opportunities for Academic Liaison with Industry (GOALI) and GOALI-like opportunities for all fields of science and engineering to include state government and non-profits, amongst other partners.
S3. *Create an NSF EPSCoR-specific Small Business Innovation Research (SBIR)/Small Business Technology Transfer (STTR) program*. A partnership could be developed such that graduate students act as Principal Investigators (PIs) on behalf of and in cooperation with small businesses. These programs can serve as a recruiting tool for co-locating and can be tailored to local workforce needs in NSF EPSCoR jurisdictions.
S4. *Provide inter-agency partnership opportunities (rather than "either-or" it's "this-and-this").* Example partnership opportunities include Economic Development Administration (EDA), Department of Commerce (DOC), and industry; in other words, a coordinated economic development strategy through inter-agency partnerships. This could include an NSF Incentivizing Collaboration and Open Research (ICOR) regional hub.
S5. *Consider how incentives can attract and retain STEM and research and development-focused businesses in an NSF EPSCoR jurisdiction to provide job opportunities to retain high-talent researchers*. It is a challenge to effectively build training opportunities for a strong workforce. Part of this work is to support the message on how universities can be drivers of economic development. NSF EPSCoR may host regional conferences to promote this message as

well as work with state legislators and other government entities to create additional opportunities for NSF EPSCoR jurisdictions.

Research and Infrastructure Capacity and Competitiveness
S6. *Fund the modernization and new construction of research facilities to include cloud-based technologies and shared servers.* NSF EPSCoR jurisdictions suffer from both a lack of and inability to maintain state-of-the-art (and sometimes basic) research facilities. This support will serve to upgrade or create novel research infrastructure to strengthen education and research. An initiative could also include capital expenditure for new state-wide shared, large or moveable equipment or core facilities, research and education computing infrastructure, communication technology, and the like. Currently, the National Institutes of Health (NIH) has such a program called the C06 Research Facilities Construction Grant.
S7. *Extend NSF EPSCoR funding to at least 10 years and allow more than one application per jurisdiction so that multiple research themes can be supported for RII Track-1 proposals.* The success of large-scale transformative NSF-supported research programs (Engineering Research Centers [ERCs], Science Technology Centers [STCs]) is a clear demonstration that significant and sustainable research advancement requires at least 10 years of strategic investments. Unfortunately, the current level of funding and duration ($20M for 5 years) does not fully enable jurisdictions to achieve sustainable excellence. A merit-based extension may also be used to extend project funding. Projects that demonstrate the greatest impact in terms of research productivity and students served; or in terms of specific sustainability activities may be renewed beyond 5 years. Additionally, NSF can provide mechanisms for submitting more than one Track-1 proposal per jurisdiction. A staggered system of overlapping Track-1s could help reduce the "boom and bust" cycle of large-scale funded programs in NSF EPSCoR jurisdictions. If multiple projects are supported from a jurisdiction, consider addressing the additional burden smaller jurisdictions may face competing with multiple applications from larger jurisdictions. If jurisdictions are allowed the opportunity to compete for additional tracks/awards, provide adequate support for the administration of multiple awards in a jurisdiction.
S8. *Build a NRT (National Science Foundation Research Traineeship) program specifically for EPSCoR jurisdictions.* NSF EPSCoR jurisdictions face significant challenges in recruiting, mentoring, and retaining high-quality and diverse graduate students.
S9. Increase the amount for the co-funding mechanism so that more grants submitted to NSF from NSF EPSCoR jurisdictions can be funded. This may increase the number of STEM research and education projects funded in NSF EPSCoR jurisdictions.

Education and Workforce Development
S10. *Support a Research Faculty Start-up Support Program (RFSSP).* The RFSSP will provide substantial support to research faculty and educators at an NSF EPSCoR institution. Funds can be used as start-up dollars to recruit new faculty to build capacity in a specific STEM area. This program needs institutional commitment for recruiting new faculty. The funds can also be requested to support student assistants or additional faculty members, new laboratory

equipment, and other infrastructure. This investment could strengthen the ability of NSF EPSCoR jurisdictions to be competitive in attracting outstanding faculty and students to advance the messaging of excellence and equity in STEM education and STEM education research.

S11. *Create a Track-1 & Track-2 supplemental funding program to increase research competitiveness and to support a broader workforce strategy*. This program would enhance the competitiveness of mid-level and junior faculty members, as well as non-tenure track faculty, at NSF EPSCoR jurisdictions that currently have Track-1 or Track-2 projects. One important aspect of this program is the ability to leverage existing investments to expand their reach across the jurisdiction, help fund early and mid-career faculty, and provide a path for sustaining research lines from diverse funding sources. In addition to Track-1 seed funding, the program would provide supplementary funding to the host Track-1 or Track-2 project to be fully invested on a new high-risk, high-payoff research effort, which will be led by the selected faculty member.

S12. *Implement a Research Experience for Undergraduates (REU) industry partnership.* Although institutions in NSF EPSCoR jurisdictions are already able to apply for REU funding to support undergraduates, this program would include a unique call for REU proposals that highlight partnerships between industry and institutions of higher education. Students would spend the academic year conducting research on campus and the summer interning in industry. This would provide students with much-needed industry experience and prepare them for multiple careers.

S13. *Support a Building Excellence in STEM Workforce (BESW) initiative.* The purpose of this new idea is to address the need for funding opportunities to build a highly-skilled, futuristic STEM workforce that can excel in a specific STEM area focusing on capabilities that are unique to the region. The goal is to build the "go-to places" for conducting advanced research to solve a certain set of STEM problems. NSF EPSCoR would fund a Track-2 type multi-jurisdictional (3 or more states) program. This program will be different from Track-2 in the following ways:
- The teams will identify the research topic that is of local relevance and uniquely positioned to build excellence;
- They will make a case for building excellence by addressing regional needs or by collaborating with local industries;
- The initiative will focus on building a highly capable workforce development by mandating that at least 50% of PIs should be tenure-track faculty members, and tenured faculty will not be allowed to serve as a PIs or a co-PI more than once in this program (this is to address the concern that Track-1 & Track-2 programs tend to have the same group of people);
- The teams can request a combination of infrastructure development and industry collaboration.

S14. *Fund sustainable research institutional management (bridge funds to maintain research administration expertise).* NSF EPSCoR research capacity development and related outcomes

are in part dependent on a competent and knowledgeable institutional management structure that can work across NSF EPSCoR projects and PI changes over time. A challenge for NSF EPSCoR jurisdictions is maintaining this highly relevant institutional management capacity. Jurisdictional NSF EPSCoR staff develop deep expertise in the required data and reporting content and processes, personnel management (often across institutions), communication and outreach, among other functions. NSF EPSCoR awards require a range of complex institutional management expertise and support critical to award function, accurate reporting, and success. NSF EPSCoR staff are positioned to provide critical program knowledge and experience that can reduce team start-up costs. Consequently, continual institutional management support for NSF EPSCoR proposal and project management within jurisdictions is key. While NSF EPSCoR does provide bridge funds to support states between awards, this has a degree of uncertainty and instability that does not support strengthening research institutional management capacity. In the current funding models, NSF EPSCoR staff are vulnerable given the inevitable uncertainty near the end of an award period and may often seek other job opportunities. In addition to maintaining existing administrative staff, additional staff may be needed to support in areas such as website development. Support could include a dedicated full-time administrative support staff for Track-1 and a shared services model for institutions to benefit from existing infrastructure.

S15. *Offset the costs of institutional research management capacity building efforts for non-research universities (MSIs and PUIs, including TYCs, etc.).* Provide funds (or supplements to existing grants) to universities and colleges with low/less overall research funding that would allow these institutions to grow/enhance their research administrative capacity to help faculty in all aspects of research and grant management.

Broadening Participation

S16. *Center MSI and PUI (including TYC) broadening participation efforts around culturally responsive, equitable, and valuable collaborations with sustainable investments*. Such collaborations will counteract current trends towards losing local highly skilled and trained young professionals (i.e., "brain drain") and cultivate multiple pathways to build STEM literacy, STEM education, STEM careers, and STEM entrepreneurship for underserved and underrepresented institutions and the communities they serve. Explicit efforts to address intersectional impact on academic disparities in STEM education and research capability should be encouraged. This requires the recognition that even within the realm of traditionally underrepresented groups in STEM, particular groups, such as persons with disabilities, neurodivergent individuals, Native Americans, Appalachians, LGBTQ+, and others, remain disproportionately underrepresented.

S17. *Support leaders and researchers at underserved or underrepresented institutions through multiple avenues.* Designate funding for new researchers and leaders at underserved and underrepresented institutions to help build the new generation of researchers and leaders. Encourage MSIs (including TCUs, HBCUs, HSIs, etc.), PUIs (including TYCs) to apply for Track-4 so

they can attract highly skilled faculty and support leaders in historically underrepresented communities.

S18. *Strongly encourage joint research and outreach with two-year colleges towards building a strong K14 pathway*, considering that many underserved or underrepresented students choose to first join two-year colleges.

S19. *Offer a program similar to NIH's Faculty Institutional Recruitment for Sustainable Transformation (FIRST),* which provides support for cluster hires of 10 or more new junior faculty members with an emphasis on traditionally underrepresented groups. NSF EPSCoR jurisdictions have significant representations from historically underrepresented groups, and such a program or other innovative practices would be critical for addressing the challenges in recruiting people from historically underrepresented groups into academic faculty positions.

This report is organized into five sections, beginning with an overview section that summarizes the subcommittee's answers to the two motivating questions followed by four topic-specific sections that align with the subcommittee's working groups.

4. INTRODUCTION

> "This challenge to America's leading role in the world's S&T enterprise is ultimately a challenge to our nation's quality of life, our economic vitality, and our national security. How we live tomorrow will be determined by the S&T decisions and investments that we make today."
>
> *-- EPSCoR 2020 Workshop Report*

In 1978, the National Science Board (NSB) established the NSF's EPSCoR program by resolution. NSF's EPSCoR was formally established in statute in 1988 to assist states that "historically have received relatively little Federal Research and Development [R&D] funding" and have "demonstrated a commitment to develop their research bases and improve science and engineering research and education."

Eligibility to participate in NSF EPSCoR activities is based on jurisdictions' demonstrated ability to obtain NSF research funds. Currently, a jurisdiction is eligible to participate in NSF EPSCoR if its level of total NSF support is equal to or less than 0.75 percent of the total NSF budget over the most recent five-year period, excluding NSF funding to other federal agencies and EPSCoR RII and workshop/conference funding. Jurisdictions above 0.75 percent but less than 0.80 percent are allowed to remain EPSCoR-eligible for up to five years. Federal obligations for research and development to all performers across the 50 states and the District of Columbia totaled $134.6 billion in FY 2019, yet one-fourth of federal research and development obligations go to the states of California and Maryland (National Center for Science and Engineering Statistics [NCSES], 2022). The uneven distribution of support for research and development in combination with existing low levels of Research & Engineering (R&E) infrastructure represent missed opportunities for the nation to grow its capacity to address national and global challenges requiring significant investments in research and infrastructure.

According to the *EPSCoR 2020 Workshop Report*, the nation's preeminence is challenged by several factors: 1) growing numbers of scientists and engineers in the world, 2) advanced scientific and technological education and research institutions across the globe, 3) the globalization of science and technology enabled by the internet, 4) increased international collaboration, 5) fewer U.S. and technological resources that exist across the country students perusing degrees in science, technology, engineering and mathematics, 6) complacency about America's preeminence in science and engineering, and 7) a failure to develop and utilize the scientific and technological resources that exist across the country.

The report further elaborates, "This challenge to America's leading role in the world's Science & Technology (S&T) enterprise is ultimately a challenge to our nation's quality of life, our economic vitality, and our national security. How we live tomorrow will be determined by the

S&T decisions and investments that we make today." The complexity of problems regarding uneven economic development, environmental problems such as erosion of coastal wetlands, and technological vulnerabilities in critical infrastructure across multiple jurisdictions require a coordinated national response.

According to the *EPSCoR 2030: A Report to the National Science Foundation*, summarizing the findings of the workshop that took place January 19th to 20th, 2012, 57 of the Fortune 500 companies are located within EPSCoR jurisdictions. Furthermore, in terms of energy production, only ten states produce more energy than they consume. Nine of those states are NSF EPSCoR jurisdictions. As discussed in that report,

> EPSCoR states account for 22 percent of the employed U.S. workforce, produce 21 percent of higher education S&E [Science & Engineering] degrees, and confer 16 percent of S&E PhDs. Furthermore, there is capacity to expand these numbers in many of the EPSCoR institutions and states. Consequently, these and other statistics show that EPSCoR states with their research universities and colleges are a huge, underutilized resource as the nation tries to keep up with the production of engineers and scientists in China, India, and other competitors. Twenty-two percent of high-technology business establishments are located in EPSCoR states. EPSCoR research institutions have a large share of U.S. academic research scientists and engineers and are the S&T centers around which high-tech companies can locate in these states creating opportunities, wealth, and quality of life. EPSCoR institutions have educated many of the engineers that support America's major companies.

Furthermore, when proportions of the population do not receive the same opportunities to advance in S&E, the entire nation suffers from the opportunity costs of increased S&E innovations, knowledge, and discovery. NSF EPSCoR is a fundamental part of NSF's strategy to reach the "Missing Millions," people who would be engaged in the STEM workforce if those areas reflected the makeup of the general population in terms of racial, ethnic and gender diversity. NSF EPSCoR recently partnered with NSF Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (INCLUDES) to introduce the NSF INCLUDES First2 Network Alliance (Award # 1834586), which provides rural, first-generation students with STEM research experiences, peer mentoring and student advocacy endeavors to improve the college enrollment rates and student success. The NSF EPSCoR Track-1 collaborative research project *Cultivating Indigenous Research Communities for Leadership in Education and STEM (CIRCLES)* (Award # 1849206) coordinates with six states in the western half of the U.S. (Idaho, Montana, New Mexico, North Dakota, South Dakota, and Wyoming) to increase representation of American Indian and Alaska Native (AI/AN) students in STEM disciplines and workforce (NSF 2021a).

Given the national challenges that have been discussed above, the mission of NSF EPSCoR is to enhance the research competitiveness of targeted jurisdictions (states, territories, and commonwealths) by strengthening STEM capacity and capability.

The goals of the program are to:

- catalyze research capability across and among jurisdictions;
- establish STEM professional development pathways;
- broaden participation of diverse groups/institutions in STEM;
- effect engagement in STEM at national and global levels; and
- impact jurisdictional economic development.

To address these goals, NSF EPSCoR uses three investment strategies: (1) RII awards that support physical, human, and cyberinfrastructure development; (2) Co-funding in partnership with NSF directorates and offices that support individual investigators and groups within NSF EPSCoR jurisdictions; and (3) Outreach activities and workshops that bring NSF EPSCoR jurisdiction investigators together with program staff from across NSF to explore opportunities in emerging areas of science and engineering aligned with the agency's strategic priorities and with jurisdictional science and technology goals.

NSF EPSCoR is committed to engaging with its external stakeholder community to better understand the impacts of its investment strategies and leverage new opportunities for increasing its success. As such, NSF EPSCoR embarked on a visioning process in March 2021 through the *Dear Colleague Letter: Envisioning the Future of NSF EPSCoR* (DCL).[1]

Image 4. Yajaira Torres-De Jesus (center) instructs students from Colegio Rosa Bell during field work as part of a Basin Resilience to Extreme Events (BREE) summer program. Source: Janel Roberge, St. Michael's College.

The purpose of the visioning process is to provide space for NSF EPSCoR and its stakeholders to deeply and collaboratively assess how the program can work most effectively with its jurisdictional partners to achieve their shared goals in the context of the Nation's changing STEM research landscape.

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[1] The impetus for the current visioning process was motivated by several concurrent factors, including the commitment to acting on evaluation findings and recommendations and compliance with the Evidence-based Policymaking Act of 2018. See [EPSCoR 2020 and 2030 reports] for more information.

Guiding this visioning process is the Committee on the Future of NSF EPSCoR, established as a subcommittee of the NSF Committee on Equal Opportunities in Science and Engineering (CEOSE). The subcommittee first convened in August 2021 and was charged with reviewing materials provided by NSF EPSCoR staff, considering written community input, conducting listening sessions with key stakeholders, and ultimately synthesizing the collected input into a summary report.

The subcommittee's work and its engagements with the broader NSF EPSCoR stakeholder community are organized around two major motivating questions:

- What does the available evidence tell us about the effectiveness of NSF EPSCoR's current investment strategies, both individually and collectively, in advancing scalable, jurisdiction-wide solutions and best practices to achieve the program's goals?

- Based on the answers to the above, are there novel strategies or changes to the current strategies that would enable NSF EPSCoR and its jurisdictional partners to achieve its mission more effectively?

To answer these questions, the subcommittee established four working groups comprised of academic experts committed to advancing the goals of NSF EPSCoR and expanding the nation's science and technology investments and outcomes. The subcommittee identified the working groups based on the overarching goals of the program: Research and Infrastructure, Education and Workforce Development, Broadening Participation, and Economic Development. These areas emerged from the visioning process as key elements and factors critical to the implementation and success of NSF EPSCoR.

The following report summarizes what was learned from these activities during the visioning process and offers recommendations.[2] In preparing its recommendations, the subcommittee considered how the program and its jurisdictional partners can effectively adapt to the changing landscape of academic research in the context of broad ongoing societal challenges, such as COVID-19, and increased STEM research competitiveness in line with NSF EPSCoR's mission. The subcommittee was also responsive to the visioning needs that were identified in the 2020 Committee of Visitors Report (COV) on the NSF EPSCoR portfolio.

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[2] This work did not employ systematic data collection. Limitations included using convenience samples in the listening sessions and time constraints that did not ensure representation of *all* relevant stakeholder groups.

5. FINDINGS AND RECOMMENDATIONS

PORTFOLIO OVERVIEW

In fiscal year (FY) 2020, NSF EPSCoR invested a total of $191.57 million in support of its programmatic activities. Of this, $148.57 million (77.6 percent) was directed to RII, $41.85 million (21.8 percent) to co-funding, and $1.76 million (0.6 percent) to outreach activities[3] and workshops. Within the FY 2020 NSF EPSCoR co-funding total, $1.25 million of support was provided through the Coronavirus Aid, Relief, and Economic Security Act (CARES Act) (P.L. 116-136).

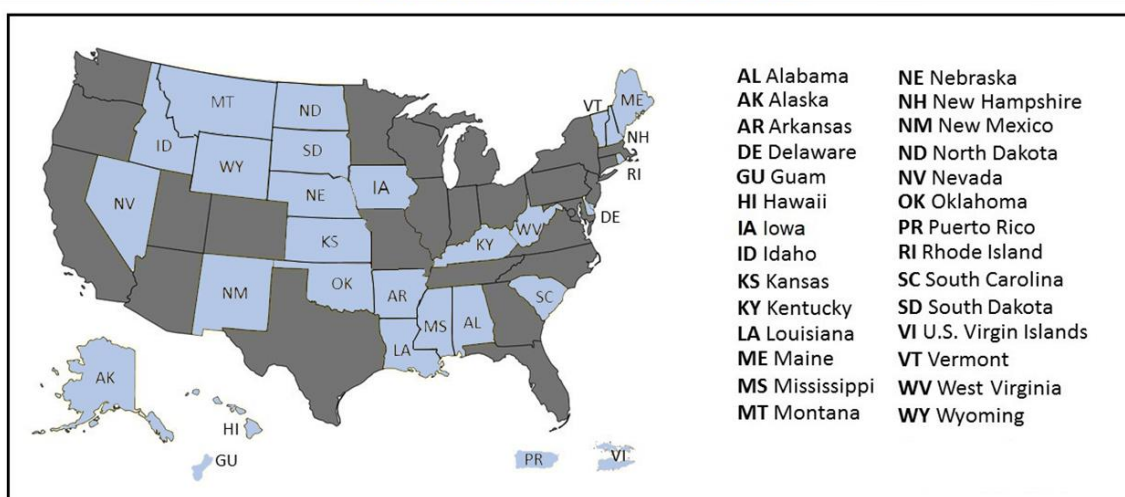## NSF EPSCoR Jurisdictions

Figure 1. NSF EPSCoR states and other U.S. jurisdictions eligible for NSF EPSCoR co-funding during FY 2022. This includes twenty-five states, Guam, Puerto Rico, and the U.S. Virgin Islands.

Track-1 provides support for sustainable improvements in a jurisdiction's academic research infrastructure that results in increased research capacity and competitiveness. Specifically, the program aims to improve jurisdictional capacity in areas of STEM research and education that are supported by NSF and aligned with the jurisdiction's science and technology priorities (NSF 22-599). Track-2 Focused NSF EPSCoR Collaborations builds inter-jurisdictional collaborative teams of NSF EPSCoR investigators in scientific focus areas consistent with NSF priorities. Projects are investigator-driven and must include researchers from at least two RII-eligible jurisdictions with complementary expertise and resources necessary to tackle those projects, which neither party could address as well or rapidly alone (NSF 22-523). Track-4 NSF EPSCoR Research Fellows provides awards to build research capacity in institutions and transform the career trajectories of investigators to further develop their individual research potential

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[3] This less than 1% of funding for outreach is in addition to the substantial outreach efforts embedded in the RII programs/tracks. NSF EPSCoR has a strong and impactful commitment to outreach.

through extended collaborative visits to the nation's premier private, governmental, or academic research centers. Through collaborative research visits at the host site, fellowship awardees will be able to learn new techniques, develop new collaborations or advance existing partnerships, benefit from access to unique equipment and facilities, and/or shift their research toward potentially transformative new directions (NSF 22-573).[4]

1. What does the available evidence tell us about the effectiveness of NSF EPSCoR's current investment strategies, both individually and collectively, in advancing scalable, jurisdiction-wide solutions and best practices to achieve the program's goals?

According to EPSCoR's 2020 COV Report, the NSF EPSCoR program supports agency-wide priorities, as documented in NSF's FY 2018 – 2022 Strategic Plan. The portfolio of programs and projects supported by NSF EPSCoR awards spans a range of emerging and innovative areas. NSF EPSCoR workshops and conferences offer an opportunity for NSF to disseminate NSF EPSCoR's advancements and common challenges across its jurisdictions, providing a venue for collaborative innovation and problem-solving.

The COV report described the management team as proactive in managing and expanding the activities and impact of NSF EPSCoR and embarking on planning efforts to increase, enhance, and ensure the quality of program activities. This includes the NSF EPSCoR team working across directorates and divisions to stimulate investments in STEM research, education, and outreach in NSF EPSCoR eligible jurisdictions. Further, the COV report noted NSF EPSCoR's commitment to continuous process improvement strategies that emphasize the importance of stakeholder engagement to identify new program ideas and ensure the quality and efficiency of existing activities, like the visioning process undertaken by this subcommittee. For example, NSF EPSCoR restructured the Track-2 solicitation to require Principal Investigators (PIs) to initiate projects that align with specific selected NSF "priority areas." The COV report noted that this change strengthened sustained collaborations in

Image 5. A University of New Hampshire senior bioengineering major Joshua Cote was part of a senior capstone project team that used a BioAssemblyBot acquired through NH BioMade. Source: Allison Wasiewski, University of New Hampshire.

[4] NSF paused Track-3 activities after the launch of a similar NSF-wide funding opportunity unveiled in 2016, NSF INCLUDES (Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science). To date, NSF EPSCoR has co-funded several NSF INCLUDES launch pilots and alliances.

interdisciplinary areas of high national and NSF priority, leading to increased jurisdictional competitiveness and capacity. Another example provided by the COV report is the creation of the Track-4 Research Fellows program, which provides early career researchers opportunities to observe, learn, and engage with premier STEM professionals throughout the nation.

In 2014, the Institute for Defense Analyses' (IDA) Science and Technology Policy Institute (STPI) collected and triangulated multiple sources of data on NSF EPSCoR, including state committee interviews, historical NSF survey data, NSF proposal and award data, journal articles, and publicly available data on gross domestic product (GDP), Carnegie classifications, and the STEM workforce to understand the effectiveness of the NSF EPSCoR program. The study found increased NSF funding, a high rate of retention for faculty hired with NSF EPSCoR funds, and improved research infrastructure and S&E education programs for earlier cohorts of the program. Although the study found that later cohorts of the program demonstrated smaller increases or more constant levels of funding, NSF funding to universities and colleges in 2014's 31 NSF EPSCoR jurisdictions increased from approximately 10 percent of total NSF R&D funding in 1980 to more than 15 percent in 2014 (Zuckerman, Parker, Jones, Rieksts, Simon, Watson III and Sedenberg et al. 2014).

STPI performed a time-series analysis using data on NSF awards to universities and colleges to explain the annual percentage change in NSF funding (minus NSF EPSCoR awards) in 2011 dollars for all jurisdictions receiving NSF grants. The best fit model found statistically significant differences in growth rates of NSF funding between early NSF EPSCoR cohorts and non-NSF EPSCoR jurisdictions, suggesting that participation in the program contributed to increased competitiveness of NSF EPSCoR jurisdictions (Zuckerman et al. 2014).[5] STPI also examined the retention of faculty hired through RII NSF EPSCoR funds supporting all of faculty members' initial salary and start-up costs. STPI collected self-reported data from NSF EPSCoR projects' annual progress reports and data calls. As of summer 2013, 78 percent (1,049 of 1,346) of NSF EPSCoR-funded faculty remained on staff at a university or college in the original jurisdiction.

STPI further reported that research bases and S&E education programs in NSF EPSCoR jurisdictions have grown substantially with support of the program, at times reaching parity with non-NSF EPSCoR states. NSF EPSCoR helped fund 66 research centers and either created or upgraded 83 laboratory facilities that were still operational in 2014. NSF EPSCoR also supported

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[5] Independent variables in the regression analysis include differences year-to-year in the number of NSF EPSCoR co-funded awards, years in the NSF EPSCoR program, annual percentage change in the number of non-NSF EPSCoR awards, annual percentage change in the difference between the largest NSF award and the median NSF award, annual percentage change in non-NSF federal R&D funding, and term accounting for the effect of recessions between 1980 and 2009. Other independent variables were not found to be statistically significant.

the creation of more than one-hundred different degree programs, including 64 PhD programs. In 1976, 4 NSF EPSCoR jurisdictions had a Research 1 (R1) institution with very high research activity. By 2011, 20 NSF EPSCoR jurisdictions had an R1 institution. Furthermore, in 2009, state governments of NSF EPSCoR jurisdictions spent on average more on R&D per unit of state GDP than was the case for state governments in non-NSF EPSCoR jurisdictions.

In its budget request for FY 2023, NSF EPSCoR provided data that demonstrated an increase in competitiveness for each cohort of NSF EPSCoR participants (NSF 2021b). For example, the 1980 cohort showed a 76 percent increase in NSF research funding over the past 41 years of EPSCoR activity while the 1985 cohort showed a 74 percent increase during its 36 years of participation in EPSCoR. Currently eligible jurisdictions participating in NSF EPSCoR since FY 2000 entered the program at a higher level of NSF research funding than the previous cohorts but have still shown a 15 percent increase in research funding.

Image 6. South Dakota State University professor Adam Hoppe indicates which single cells are being sorted to analyze their properties to see if the genes inhibit or contribute to viral infections. The research is funded by a one-year, $200,000 National Science Foundation grant, which Hoppe recently received through NSF's Rapid Response Research mechanism to address the COVID-19 pandemic. Emily Weber, South Dakota State University.

Supporting evidence for question 1 from the listening sessions and stakeholder public comments is included throughout the remaining sections. Evidence-at-glance of major accomplishments related to the five EPSCoR goal areas at the aggregate, jurisdictional and selected grantee level is presented as highlights across the grantee portfolio and is not exhaustive of all the work and impacts of each EPSCoR awardee. Please see Appendix A for TABLE 2. EPSCoR Making a Difference: Evidence in Support of Investment Strategies by Programmatic Goals for these highlights.
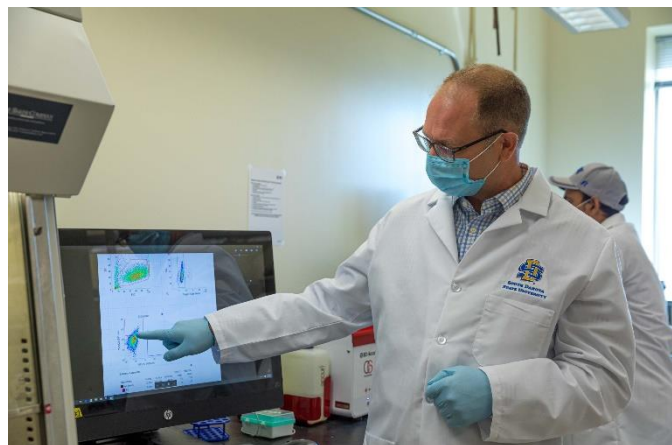
2. Based on the answers to the above, are there novel strategies or changes to the current strategies that would enable NSF EPSCoR and its jurisdictional partners to achieve its mission more effectively?

The subcommittee reviewed the available evidence and provided actionable recommendations and suggestions in the sections below. Although these data provide evidence for the types of advances NSF EPSCoR has made toward its program goals, there is still room for progress to be made. An unpublished study by 2M Research (2020) found that on average, NSF EPSCoR jurisdictions ranked lower than non-NSF EPSCoR jurisdictions on 26 outcome variables related to human capital production, reputation in knowledge production, and economic development of high-tech industry. These findings suggest the need for new ideas on how to reduce the gaps between NSF EPSCoR and non-NSF EPSCoR jurisdictions in research competitiveness and capacity.

The evidence above demonstrates the successes and impacts of NSF EPSCoR on participating jurisdictions in the growth and sustainability of research funding, increased faculty retention, and improvements in research infrastructure and competitiveness. To bolster and expand these efforts, the subcommittee has identified eight recommendations, providing two recommendations for each of the four working groups: Research and Infrastructure Capacity and Competitiveness, Education and Workforce Development, Broadening Participation, and Economic Development. Common across the recommendations are three broad foci: 1) Expanding and Supporting Human Capital; 2) Bridge-building; and 3) Strengthening Resources and Infrastructure, with Inclusion and Diversity undergirding these three main areas.

Expanding and Supporting Human Capital. One common theme within the recommendations is supporting and expanding efforts to recruit a greater number of STEM faculty, students, and supporting staff within NSF EPSCoR jurisdictions. Many recommendations not only focus on efforts to recruit accomplished faculty researchers and educators to participating jurisdictions, but also on creating meaningful professional opportunities for STEM undergraduate and graduate students. Further, providing technical support and personnel for research staff can help boost the effectiveness of researchers in navigating challenges, logistics, intellectual property development, and partnerships. Finally, recommendations identified the need for investment in programs and activities that provide continuous professional development throughout career trajectories and pathways to encourage advancement and retention.

Bridge-building. Across the recommendations and in line with Track-2 priorities, NSF EPSCoR was identified as a potential bridging mechanism for creating, expanding, and strengthening partnerships and collaborations between jurisdictions, institutions, corporations, private research centers, and communities. Acknowledging the value of leveraging expertise, resources, and innovative ideas, the subcommittee asserts that NSF EPSCoR has a unique

opportunity to not only encourage but require partnerships within and across NSF EPSCoR and non-NSF EPSCoR jurisdictions, particularly the sharing of ideas and synergies through collaborative proposals for research that aligns to NSF priority areas. Partnerships should also be expanded beyond jurisdictional institutions to include coordinated and strategic work with private enterprises and centers, K-12 schools, community organizations, and federal agencies. These bridge-building strategies can heighten capacity and competitiveness, as well as broaden NSF's reach to other sectors beyond individual institutions and jurisdictions.

Strengthening Resources and Infrastructure. While NSF EPSCoR provides support for physical, human, and cyberinfrastructure development as aligned to Track-1, recommendations call for further investments. The subcommittee identified the need for NSF EPSCoR to target jurisdictional investments on the construction and/or modernization of research facilities, tools, processes, and systems intended to maximize efficiency for increased research and economic development. Embedding technical assistance from NSF within these funding opportunities would aid in addressing logistics, communication, and barriers for which NSF EPSCoR participants may not have capacity.

Image 7. Dr. Colleen Scot working with her graduate student, Ishanka Rajapaksha in the lab. Source: Emily Green, Mississippi State University.

Inclusion and Diversity. Cross cutting the above three foci is NSF EPSCoR's demonstration of its commitment to promoting inclusion and diversity in culturally responsive ways within and across jurisdictions. Inclusion and diversity include broadening opportunities for faculty and student populations traditionally underrepresented in STEM research and careers and *intentionally* engaging members of these populations throughout their involvement in NSF EPSCoR, including serving on expert panels, committees, and commissions. NSF EPSCoR can also broker inclusive and diverse partnerships not only with individual investigators, but also institutions (for example, MSIs and PUIs) and underserved communities and K-12 schools. Likewise, providing additional investments to engage students and faculty who aim to pursue STEM careers through various pathways apart from the traditional career pathway would expand reach and broaden inclusion and participation. Requiring applicants to commit to inclusive practices, such as building diverse research teams or center activities within areas where there are less resources and infrastructure would help ensure NSF EPSCoR is committed to broadening representation in STEM research and professions. Finally, the recommendations suggest that there should be an intentional integration and inclusion of NSF EPSCoR and its strengths and priorities within and across the Foundation to encourage deeply collaborative partnerships across the agency.

Cross-cutting Ideas to Strengthen NSF EPSCoR

The following section provides some cross-cutting ideas that would support implementing the broader areas discussed above.

Expanding and Supporting Human Capital

EPSCoR jurisdictions face significant challenges in recruiting, mentoring, and retaining high-quality and diverse junior faculty. NSF may develop programs that support initiatives similar to the NIH Institutional Development Award Centers of Biomedical Excellence (IDeA COBRE) programs. In these programs, each institution identifies a theme and recruits up to five junior faculty and provides mentorship so that the junior faculty become successful independent scientists. These faculty members are provided significant start-up funding for research and support throughout their award. The duration of each award is 5 years, renewable twice for a total of 15 years (Phase 1-3).

Bridge-building

NSF can develop a Big Transformative Ideas framework for EPSCoR jurisdictions that enhances research capacity by expanding both EPSCoR inter-jurisdictional and EPSCoR-non-NSF EPSCoR collaborations involving common research themes. The bridge-building initiatives must be led by EPSCoR PIs and the non-NSF EPSCoR co-PIs would be funded with non-NSF EPSCoR dollars. This program will allow EPSCoR jurisdictions to join forces with non-NSF EPSCoR jurisdictions with complementary strengths and expertise. The non-NSF EPSCoR co-PIs should demonstrate how the proposed collaboration would enhance the research capacity of the EPSCoR state. With adequate funding, such collaborating multi-jurisdictional initiatives will become sustainable powerhouses with expertise in specific themes and can serve the entire nation for years to come.

Strengthening Resources and Infrastructure

NSF can adjust EPSCoR program funding amount and duration to more accurately reflect the extended timeline for sustainable capacity-building and economic development. Additional funding and prolonged funding cycles support the construction and modernization of research facilities, other infrastructure, and research instrumentation.

Support the development of an infrastructure database in partnership with EPSCoR State Committees to inventory science and technology buildings within jurisdictions and current conditions of research spaces. Such an initiative would support PUIs, including TYCs and HBCUs, Hispanic-Serving Institutions (HSIs), and Tribal Colleges and Universities (TCUs) and other MSIs,

which may have limited physical infrastructure and a lack of brick-and-mortar funding opportunities. These facilities could be shared across institutions.

Inclusion and Diversity

To address inclusion and diversity, NSF can embed geographically diverse capacity-building in all NSF programs. Each NSF directorate must fully integrate the capacity-building mission directly into their divisions and programs to create NSF-wide programs that are inherently capacity-building. This strategy is similar to the integration of broadening participation across initiatives rather than attempting to "retrofit" programs with capacity-building provisions after the fact. The intention here is not to replace the EPSCoR program, but to support economic development across geographically diverse regions. Additionally, it is important that EPSCoR's representation on high-profile science and engineering advisory committees and boards be increased and that the committees and boards continue to encompass researchers from a wider geographical span.

Build equitable collaborations that avoid a "one-size-fits-all underrepresented institutions" approach to the participation of MSIs, PUIs in EPSCoR funding. Collaborations with these institutions should be rooted in the varied niches, interests, strengths, and goals of the individual institution.

The remaining sections detail the available evidence and provide the eight actionable recommendations across the four working groups.

Image 8. A group of students from the Wesley College Success in STEM (SIS) program visit the Smithsonian on a trip to Washington D.C. Source: Dr. Kevin Shuman, Wesley College.

The Relationship Between the Four Focus Areas in the Report

Jurisdictional economic development is fundamentally tied to strengthening research and infrastructure competitiveness and capacity, education and workforce and broadening the participation of diverse groups in these areas to catalyze science, innovation, and discovery (Figure 2). The scientific endeavor, particularly in STEM fields, has grown from a model of basic science as the primary driver of innovation and prosperity to a more integrated "triple helix" that incorporates universities, industry, and government (Bentley et al. 2015). With this recognition, EPSCoR not only aims to foster fundamental scientific discovery, but also to aid interdisciplinary and translational activities that expand the benefit of basic discoveries to as

many people as possible. At the core of this exercise is an understanding that synergies between basic, applied, and translational (development) science, smaller and larger educational institutions, traditionally represented and underrepresented groups, and public and private entities must be nurtured to address regional needs in an effective and equitable manner. It is also central that sustainable economic growth be rooted in unbiased access to educational opportunity as a conduit to a diverse workforce capable of guiding scientific discovery and implementation.
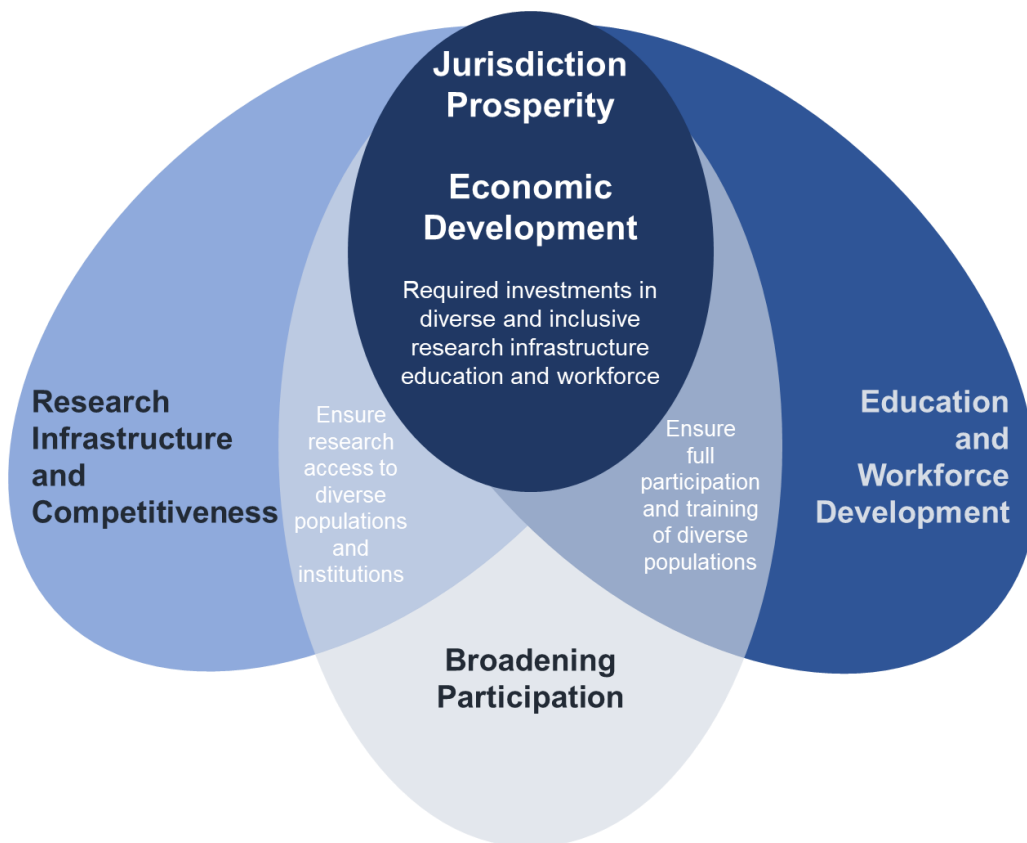

Figure 2. The Relationship between Economic Development, Research and Infrastructure, Education and Workforce Development, and Broadening Participation.

ECONOMIC DEVELOPMENT

To ensure a strong science and technology-based economy throughout the nation, EPSCoR jurisdictions must serve as hubs for the research and education enterprise, enabling discovery and innovation. Outcomes include job creation and the expansion of a talented workforce prepared to ensure global competitiveness both now and in the future.

Economic development occurs over an extended timeline, but critical steps must be in place to enable the long-term economic gain. Basic research (such as via an RII Track-1) is the foundation of such expansion, followed by partnership formation surrounding a key area, for example, with the private sector, and ultimately expanded partnerships that include a range of institutional types. When research initiatives center around regional excellence, drive innovation, and welcome partnerships for diversified investments and longer-term support, jurisdictions will observe gains in workforce, economic benefit, and a highly stable impact.

There are three levels through which we consider economic impact (Figure 3). First, the RII Track-1 awards enable teams to form and develop impacts. Second, new partnerships are formed to provide more stable impacts. Finally, regions benefit from a more comprehensive economic stability across NSF EPSCoR jurisdictions.

> *"Allowing jurisdictions to build collaborative proposals, such as Track-2, around priority focuses and strengths consistent with NSF EPSCoR rather than limiting [them] to NSF-specified areas could help jurisdictions build the targeted strengths needed to be recognized as national leaders and build the economic capacity in strategic areas in which the states are investing.''*
>
> *– Listening Session Participant*
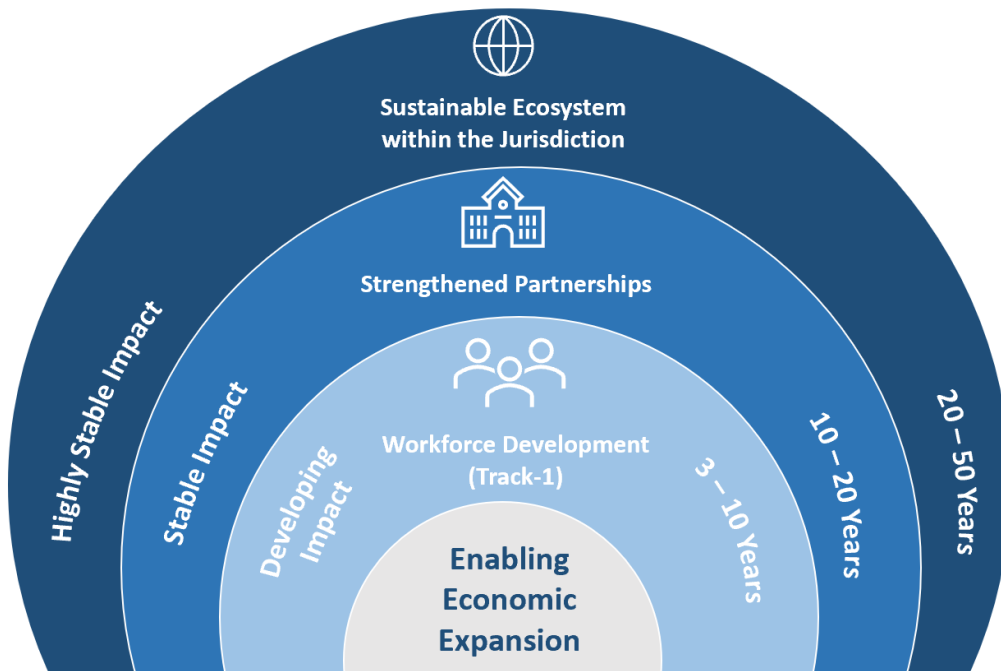
Figure 3. Levels of Economic Impact

Some attributes of an economic hub of innovation are subjective, but the subcommittee identified what it considers to be fundamental contributions (Figure 4). The first contribution is a robust research infrastructure with broadband, cybersecurity, and technology support and the foundation for establishing a research program. The second contribution is an effective knowledgebase and opportunities for partnerships to diversify and expand the reach of funding opportunities needed for sustainability. The third contribution is support for the expansion of infrastructure and new business formation, such as university-affiliated start-ups and memorandums of understanding with key entities in the private sector to ensure translation of the work more broadly. The fourth and final contribution is regional economic gains that are recognized nationally and internationally.

Figure 4. Sustainable Economic Development

NSF EPSCoR jurisdictions could serve as the backbone of American innovation and further support the expansion of research and development, if properly scaled and resourced, and coupled with capacity building programs for longer-term success at every level. Beyond support for basic research, investment in physical and administrative capacity within NSF EPSCoR jurisdictions is a critica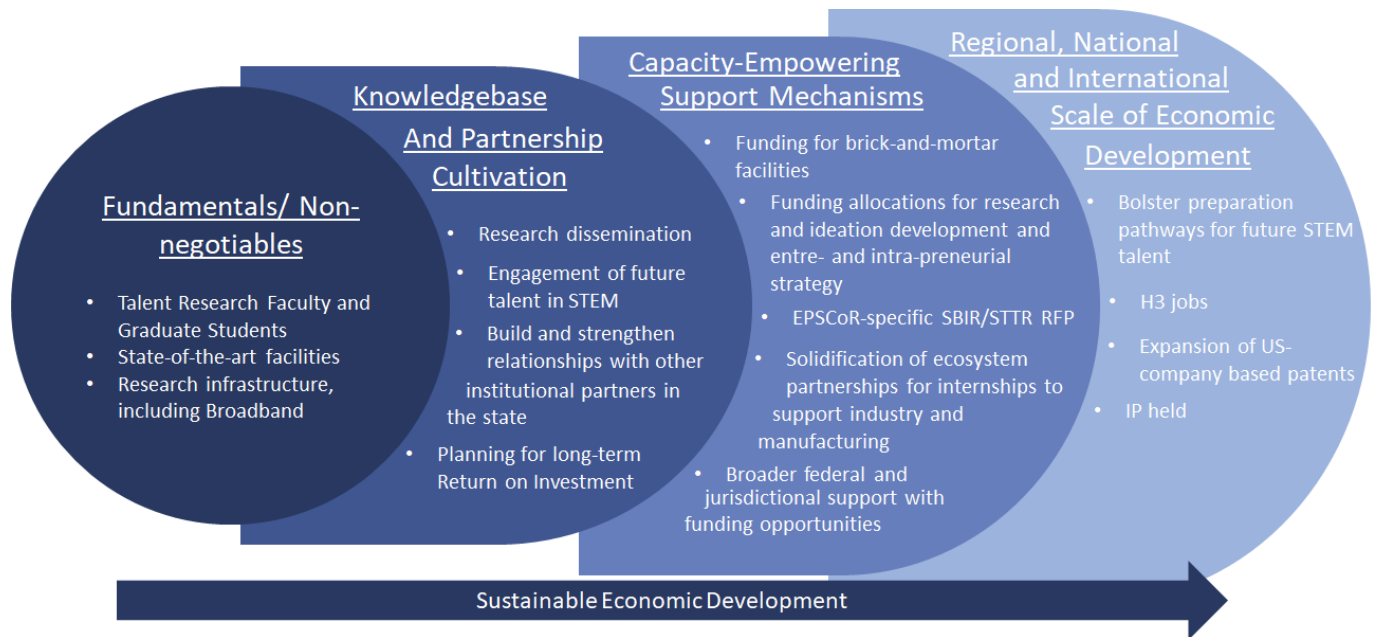l capacity-empowering support mechanism. However, NSF EPSCoR is not intended to be, nor can it succeed as, a standalone economic development program. Rather, a coordinated, concerted effort toward meaningful STEM capacity building with genuine buy-in from jurisdictional constituents and collaborative resourcing from a range of federal sponsors is needed to support a wider expansion of economic development. Current NSF public-private partnership programs beyond NSF EPSCoR do not fully integrate capacity building as a fundamental component, and as such, many EPSCoR jurisdictions find that there is little support on the path to successful economic development after a RII Track-1 award.

The subcommittee's recommendations are based on findings from a review of extant data and input from listening session participants and stakeholders who submitted public comments. First, there is a lack of unified, consistent tracking methods to determine the impact of NSF EPSCoR on economic development. Second, NSF EPSCoR jurisdictions struggle to secure funding for centers such as NSF STC and ERC awards and face similar competitiveness challenges in other national federally funded programs with the potential to contribute to economic development. Of 60 NSF centers in 2019 representing $184 million in funding, only one center was led by an institution from an NSF EPSCoR jurisdiction. Of the 17 active NSF STCs, there are

no lead institutions and only two partnering institutions from NSF EPSCoR jurisdictions. Since the beginning of the STC program in 1989, there have only been three awards to NSF EPSCoR jurisdictions: The University of Oklahoma (1989), The University of Kansas (2005), and The University of Hawaii (2006). For FY 2021, there was no lead institution from any NSF EPSCoR jurisdiction to be awarded an STC. Similarly, of the 15 active NSF ERCs, none are in an NSF EPSCoR jurisdiction (NSF 2021c).

Listening session participants noted several ways that NSF EPSCoR funded STEM capacity has increased economic development; for example, through job creation resulting from partnerships between the private sector and faculty, national labs supporting small businesses, and the promotion of STEM through partnerships with informal science organizations. Stakeholders who submitted public comments also mentioned successes that include NSF EPSCoR-supported startups, seed grant funding, and commercial applications. Stakeholders recommended that NSF fund strategies to link NSF EPSCoR to SBIR and STTR programs, offer incentives to the private sector to partner with NSF EPSCoR institutions, and invest in startup companies through Track-1.

NSF can foster capacity-building and effect change with membership on the Directorate and Office Advisory Committees that more fully represents NSF EPSCoR jurisdictions, particularly as NSF EPSCoR jurisdictions represent around 20% of the U.S. population and include 24% of the nation's African American population, 49% of the nation's Native Hawaii and Pacific Islander population, 40% of the nation's Native American population, and 50% of the country's HBCUs. Additionally, NSF EPSCoR jurisdictions represent 16 percent of the U.S. Hispanic population and 68 % of tribal colleges and universities (Ecological Society of America [ESA] 2014). Further, representatives from NSF EPSCoR jurisdictions must be included as ad hoc reviewers, panelists, and members of the Committee of Visitors at a rate commensurate with their representation in the U.S. The opportunities for embedding EPSCoR into more of an ecosystem-based approach is captured well via the new Gen-4 Engineering Research Centers solicitation (NSF 22-580), highlighting collaboration across agencies. Expanded collaboration inter- and intra-agency will help to further enable economic development opportunities.

Recommendations

R1. **Ecosystem Approach to Investments:** NSF should partner with other federal agencies to create new programs for coordinated and long-term strategic investment that will ensure capacity and support from the basic science questions through commercialization, job creation, and workforce support, while also expanding and using the internal EPSCoR co-funding mechanism and considering programs to encourage collaboration between NSF EPSCoR and non-NSF EPSCoR jurisdictions.

R2. **Increased Integration of NSF EPSCoR:** NSF should adopt a more holistic view of NSF EPSCoR with a greater integration of NSF EPSCoR across the Foundation and more cross-fertilization between the NSF EPSCoR Office and the balance of the Foundation and focus on developing internal programs that are more inclusive of the strengths and scientific priorities of NSF EPSCoR jurisdictions.

RESEARCH AND INFRASTRUCTURE CAPACITY AND COMPETITIVENESS

Research competitiveness is inherently tied to scientific talent and creativity, but competitiveness is also built on an indispensable foundation of facilities, instrumentation, technical and supporting staff, private partnerships, and in the era of team science, a *critical mass* of diverse and inclusive researchers and their students for collaboration (Figure 5). These essential foundations are more fully established and better funded in non-NSF EPSCoR jurisdictions that have historically been supported by decades-long federal and state R&D investments and which have also benefitted from stronger industrial ties and larger population centers. The growing inequity in research infrastructure between NSF EPSCoR and non-NSF EPSCoR jurisdictions puts EPSCoR jurisdictions in an endless cycle of catch up, and has had a negative effect on NSF EPSCoR jurisdictions' ability to grow STEM capacity and thereby meaningfully contribute to their regional economies.

> *"Looking backwards, those Track-1 grants have made lasting and positive impacts in several key areas: 1) the formation of centers and institutes; 2) expansion physical and computing infrastructure; and 3) faculty hiring. RII Track-1 investments in Maine have funded the creation or expansion of five research centers, three institutes, and eleven laboratories since 1980."*
>
> *– Stakeholder Public Comment*

> *"The current investment strategy of RII Track-1 awards has provided the greatest impact. In Kansas, early investments into research clusters, along with planning grants have led to two Center designations from NSF awards."*
>
> *– Stakeholder Public Comment*

As the two quotes from stakeholders demonstrate, while there is opportunity for greater integration of EPSCoR into the Foundation, EPSCoR has resulted in major achievements in terms of research infrastructure for jurisdictions. The subcommittee noted clear agreement among NSF EPSCoR stakeholders that the program has significantly helped jurisdictions improve and enhance research capacity and competitiveness. For example, listening session participants described establishing new collaborations; developing patents, startups, and technologies; purchasing state-of-the-art equipment; and making investments in educational outreach from K-12 through higher education that would not have happened without NSF EPSCoR funding. Similarly, stakeholders who submitted public comments discussed successes in hiring faculty and providing them with mentorship, enhancing physical and computing infrastructures, leveraging NSF funds to obtain additional resources, and sustaining existing research programs because of NSF EPSCoR.

Figure 5. Research and Infrastructure Graphical Representation

Listening session participants and stakeholders who submitted public comments suggested areas for additional support from NSF EPSCoR such as programs to promote the recruitment, retention, and training of faculty, researchers, and graduate students in NSF EPSCoR jurisdictions; purchase new equipment and maintain and repair existing equipment; and provide start-up funds. Stakeholders also emphasized the need for flexibility to identify and fund projects relevant to local jurisdictional interests, those of relevance across multiple EPSCoR jurisdictions and the ability to fund more projects per jurisdiction for longer periods of time.

Recommendations

The subcommittee recommends that NSF address structural inequities in STEM, among NSF EPSCoR jurisdictions, through enhanced long-term strategic investments that support the infrastructure needs and promote the unique research capacities, talents, and opportunities in NSF EPSCoR jurisdictions.

R3. **Diverse Talent Recruitment and Retention**: NSF should expand investments to grow the critical mass of highly competitive and capable faculty, technical staff and students in NSF EPSCoR jurisdictions and develop new grant programs that will help build nationally competitive, sustainable research, and promote collaborations within and across NSF EPSCoR jurisdictions and beyond.

R4. **Physical and Administrative Infrastructure:** NSF should invest in physical and administrative infrastructure in EPSCoR Jurisdictions that support research and economic development. This includes construction or modernization of research facilities and infrastructure, research instrumentation, and staff to support intellectual property development, commercialization, and corporate engagement—all of which are essential for building the research infrastructure for sustainable research and economic competitiveness in NSF EPSCoR jurisdictions.

EDUCATION AND WORKFORCE DEVELOPMENT

Research is inherently a social enterprise. NSF EPSCoR supports the development of research teams by funding large multi-disciplinary and often multi-institutional projects. NSF EPSCoR jurisdictions provide significant and unique opportunities for students, postdoctoral fellows, and faculty by offering research opportunities that are instrumental in their careers (Figure 6).

"NSF EPSCoR has resulted in the ability to recruit top faculty, offer new programs and degrees, train thousands of students, support existing industry in the state and region, catalyze new technical startups, and win large competitive rewards."

- *Public Comment Respondent*

The various tracks in the EPSCoR portfolio have been complementary to NSF's STEM educational programs designed to enhance curricula, instruction, assessment, professional development and advancement, and research collaboration of all types of higher education institutions in the EPSCoR jurisdictions. However, as noted in the recent NSB Science and Engineering Indicators reports, increased attention needs to address STEM education challenges like: monitoring of state level data of S&E degrees as a percentage of higher education degrees conferred, how to leverage the strength of institutional diversity and mitigate the differential impacts of the COVID-19 pandemic, recruitment and retention concerns related to college affordability and time to degree completion, deeper dive of disciplinary trends and readiness for emerging S&E fields, and innovative global engagement at multiple levels.

The foundations for an adaptable and innovative workforce begin in the classroom. To adapt to the changing economic context, developing inclusive opportunities for STEM learning for students that begins in the K-12 classrooms and continues through college and graduate school is an essential step toward building high skilled faculty within EPSCoR jurisdictions. By creating pathways for students to build expertise in STEM areas and pursue their chosen careers, mentoring and hands-on research build capacity. EPSCoR has been beneficial for undergraduate and graduate students to be involved directly in laboratory research and experience mentoring from faculty in their fields.

Listening session participants commented on the beneficial career development opportunities provided by NSF EPSCoR, such as research and lab exchanges in which institutions worked together to provide mentorship, conduct research, and develop the careers of advanced students and postdocs. Stakeholders who submitted public comments discussed how NSF EPSCoR has provided funding to hire undergraduate, graduate, and post-doctoral students to support their research and training by offering student development and educational opportunities to build expertise in STEM areas.

NSF EPSCoR jurisdictions currently face challenges in attracting and retaining academically outstanding students and competitive researchers who can take full advantage of various

Figure 6. Education and Workforce Development Graphical Representation

research and training opportunities to build sustainable programs. Although listening session participants highlighted the importance of developing their jurisdiction's physical research infrastructure, most of their specific infrastructure-related recommendations focused on developing their jurisdiction's human infrastructure. A common theme across listening sessions was the need for NSF funding to improve research management and project administration capabilities for those in project or EPSCoR-office leadership roles. Participants described this as an area of weakness across many NSF EPSCoR institutions that significantly limits their ability to compete for funding. Listening session participants also recommended funding release time for faculty so that they can engage more fully in research activities, investing in more research opportunities for students, providing opportunities for individuals to network and participate in career-building activities such as review panels, and establishing comprehensive and inclusive mentoring services or programs. Stakeholders who submitted public comments also recommended that NSF provide additional funding for creating a track focused specifically targeting workforce development activities that can engage talent from the private sector.

Recommendations

The subcommittee's recommendations to address education and workforce development needs are guided by three principles. First, targeting the needs of individuals and institutions within and across a jurisdiction can create sustainable synergies that contribute to research

capacity. Second, NSF EPSCoR opportunities need to be developed across jurisdictional boundaries, offering opportunities for cross pollination and capacity building. Finally, NSF EPSCoR is in a strong position to enhance inclusion and diversity through opportunities presented by its awards. It is assumed within these recommendations that appropriate and innovative curricula and educational pathways are in place and/or developed to ensure broad student access and participation.

R5. **Programs to Promote Intra- and Inter-jurisdictional Research, Education, and Workforce Development:** NSF should explore opportunities to fund collaborative proposals across multiple jurisdictions. Interjurisdictional opportunities could support topics of shared interest that are identified by the proposing project team that would leverage existing expertise and resources with the goals of promoting synergistic research, workforce development, and educational activities that can broaden impacts well beyond what single jurisdictions (particularly smaller ones) can accomplish. Providing such opportunities for collaboration also enables brain circulation and network development across multiple jurisdictions. Large intra- and inter-jurisdictional grants could have provisions to enable funding requests for recruitment and retention of young faculty, thereby building a sustainable workforce.

R6. **Support for Workforce, Including Those with Diverse Career Pathways:** NSF should expand research and collaboration opportunities and related career support and mentoring for individuals at different career stages and pathways within NSF EPSCoR funding programs. EPSCoR projects provide rich and often unique opportunities for early career researchers that can be instrumental in their career advancement, for both academic and other broad career paths. Similarly, mid-career researchers can experience significant advantages in research leadership and advanced publication and grant opportunities that matter for promotion and professional recognition, particularly among underrepresented groups. Specific attention to these two critical career stages would create a deliberate and parallel effort to other NSF programs that prioritize opportunities for pre-tenure as well as pre-promotion mid-career faculty.

Because RII Track-1 and Track-2 funding provides the resources and foundation for team development, student training, and knowledge creation efforts, the subcommittee recommends that additional and deliberate attention must be paid to improve these programs and to build other programs or tracks that build the social and human capital of trainees and early and mid-career researchers in NSF EPSCoR jurisdictions.

Image 9. Marguerite Kennish adjusts an instrument at the John Olson Advanced Manufacturing Center at the University of New Hampshire. Kennish, one of six NH BioMade transfer scholars, entered the four-year mechanical engineering degree program at UNH after graduating from Great Bay Community College with an associate's degree in engineering sciences. Source: Jeremy Gasowski, University of New Hampshire Communications and Public Affairs.

BROADENING PARTICIPATION

In their most recent report to Congress, CEOSE stated, "As the nation's population of underrepresented and underserved groups grows, the inclusiveness of people from diverse backgrounds is foundational to the success of the nation's science and engineering enterprise" (CEOSE 2020). Furthermore, the CEOSE report specified, "STEM leaders from underrepresented groups, including Black or African American, Hispanic or Latino American, American Indian or Alaska Native, persons with disabilities and women, provide the different cultural perspectives necessary to solve the broad spectrum of human problems" (CEOSE 2020: 10). These perspectives are necessary to catalyze science, discovery, and innovation. However, the NSB noted in its Vision 2030 report that while participation of underrepresented groups in the STEM workforce has grown, it does not reflect the proportion of underrepresented groups in the larger U.S. population (NSB 2020).

> *EPSCoR is a fundamental part of NSF's strategy to reach the "Missing Millions," people who would be engaged in science, technology, engineering, and mathematics (STEM) workforce if those areas reflected the makeup of the general population in terms of racial, ethnic and gender diversity.*
>
> *- NSF EPSCoR*

Image 10. Graphical Representation of Broadening Participation in STEM. Source: 2017-2018 CEOSE Biennial Report

To reach that goal, "the NSB estimates that the number of women must nearly double, Black or African Americans must more than double, and Hispanic or Latinos must triple the number that are in the 2020 U.S. S&E workforce" (NSF 2020). Reflecting on these disparities, the NSB refers to individuals from underrepresented populations not engaged in STEM as "the missing millions." Similarly, the National Academy of Sciences, Engineering, and Medicine (NASEM) points to two valuable but underutilized resources in the STEM enterprise: the more than 20 million people of color whose participation in STEM does not match their proportions in the

U.S. population and the more than 700 MSIs that trains nearly 30 percent of undergraduates in the country (NASEM 2019).

> *"I'm from a tribal college. So, our students, almost by default, end up broadening participation. And a lot of the research-based work that happens on my campus is culturally tied to the needs that exist in our communities and it's driven by researchers on my campus who are native, who are indigenous."*
>
> *-- Listening Session Participant*

The EPSCoR program offers an opportunity to increase "support for place-based implementation research projects that are grounded in and engage local communities" (CEOSE 2020:10) and increase the level of diversity and inclusion in the STEM workforce. NSF has held a longstanding commitment to broadening participation through a variety of investment priorities that include preparing a diverse, globally engaged STEM workforce; integrating research with education and building capacity; expanding efforts to broaden participation from underrepresented groups and diverse institutions across all geographical regions in all NSF activities; and improving processes to recruit and select highly qualified reviewers and panelists. With its focus on expanding the distribution of federal research funds and increasing STEM competitiveness and capacity in eligible jurisdictions, NSF EPSCoR is well-positioned to foster greater participation in STEM for people from underrepresented groups such as Black or African Americans, Hispanic or Latino Americans, American Indians and Alaska Natives, persons with disabilities, and women.

Listening session participants and stakeholders who submitted public comments often highlighted NSF EPSCoR's support for diversity and inclusion among faculty, students, and research communities. Participants across listening sessions discussed ways to broaden the participation of PUIs and MSIs in NSF EPSCoR. These ideas included creating a separate RII track focused on funding PUIs and MSIs, providing more funding to PUIs and MSIs partnered with RII institutions, funding release time for faculty at these institutions for whom high teaching loads are often a barrier to research, and convening PUI- and MSI-driven workshops for participants to discuss common issues and potential partnerships. Stakeholders who submitted public comments also provided recommendations to specifically involve more individuals from underrepresented groups including the direct funding of research professorships in NSF EPSCoR jurisdictions to increase faculty diversity and the involvement of diverse stakeholders in all stages of STEM research.

Recommendations

The subcommittee encourages the implementation of the pathways model of broadening participation, which employs "multiple routes toward the required training for science careers and that the underlying problem is not the undersupply of graduates in science but barriers that undervalue these alternative routes taken by women and minorities" (Fealing, Lai, and Myers 2015). By focusing on the pathways model, NSF EPSCoR can promote STEM education, research, employment, and culturally responsive collaboration, in which there is a commitment to learning from and relating respectfully to others who are both similar and different from oneself. By promoting pathways to a brighter social and economic future, NSF EPSCoR can rise above being considered a source of funding to a transformative program that establishes national standards and best practices in culturally responsive educational, social, and economic developments (Feeling et al. 2015). More importantly, the subcommittee agrees with CEOSE that recommendations in this area must reflect that broadening participation is an asset for doing better science by embracing diverse perspectives and ensuring equitable opportunities in STEM.
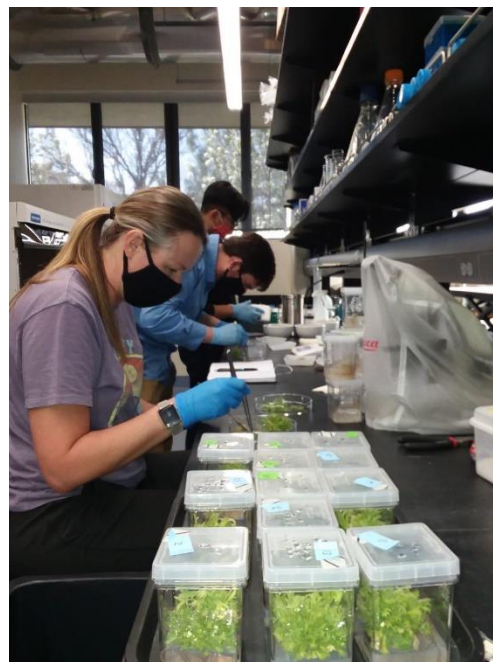
Image 11: Genes by Environment (GEM3) researchers at Boise State University collecting biomass serving as basis to assemble the sagebrush genome. Source: Sven Buerki, Boise State University

R7: Proactive Inclusion Strategies: Proactive Inclusion Strategies: NSF should be accountable for the formation of diverse teams of researchers via partnerships between EPSCoR jurisdictions and researchers from underrepresented groups in all pre- and post-award facets of the EPSCoR program, such as inclusion in panels, committees, commissions, and review boards. EPSCoR researchers, especially those from underrepresented groups, need greater inclusion on NSF panels and advisory committees.

R8. Access and Opportunity: NSF should enhance geographic diversity by providing greater infrastructure support for TCUs, HBCUs, HSIs, and other MSIs and PUIs, including TYCs, to engage in research efforts and enhance collaborations with external partners. Support must also include technical assistance to address gaps in research administration, funding of brick-and-mortar research facilities, institutional and interinstitutional research collaborations, and establishment of innovative mentoring partnerships. In addition to providing support, EPSCoR must shift to tracking impactful outcomes to inform subsequent support.

In addition, access and opportunities include addressing institutional needs like diversifying the STEM workforce through cluster hires, increasing financial and infrastructure support to MSIs, and promoting the visibility of MSIs beyond Track-1 to build leaders in underserved/ underrepresented communities.

6. CONCLUDING THOUGHTS

This report catalogues the accomplishments of NSF EPSCoR in terms of economic development, research and infrastructure capacity and competitiveness, education and workforce growth and broadening participation in STEM. While much has been accomplished, the Committee on the Future of EPSCoR recognizes that there are unique opportunities to expand the capacity and competitiveness of EPSCoR jurisdictions with additional support. The Committee offered eight recommendations and 19 suggestions to inform future development of the program. The request for additional capacity building for NSF EPSCoR does not seek to remake NSF EPSCoR jurisdictions into non-NSF EPSCoR jurisdictions, but rather to expand pathways of opportunity that will benefit the entire nation in terms of growth and innovation. How can NSF EPSCoR jurisdictions continue activities following a Track-1 award, for example, through establishing an NSF-funded Science and Technology Center (STC), Engineering Research Center (ERC), or regional innovation accelerator or hub? How will NSF EPSCoR lead the way in creating new
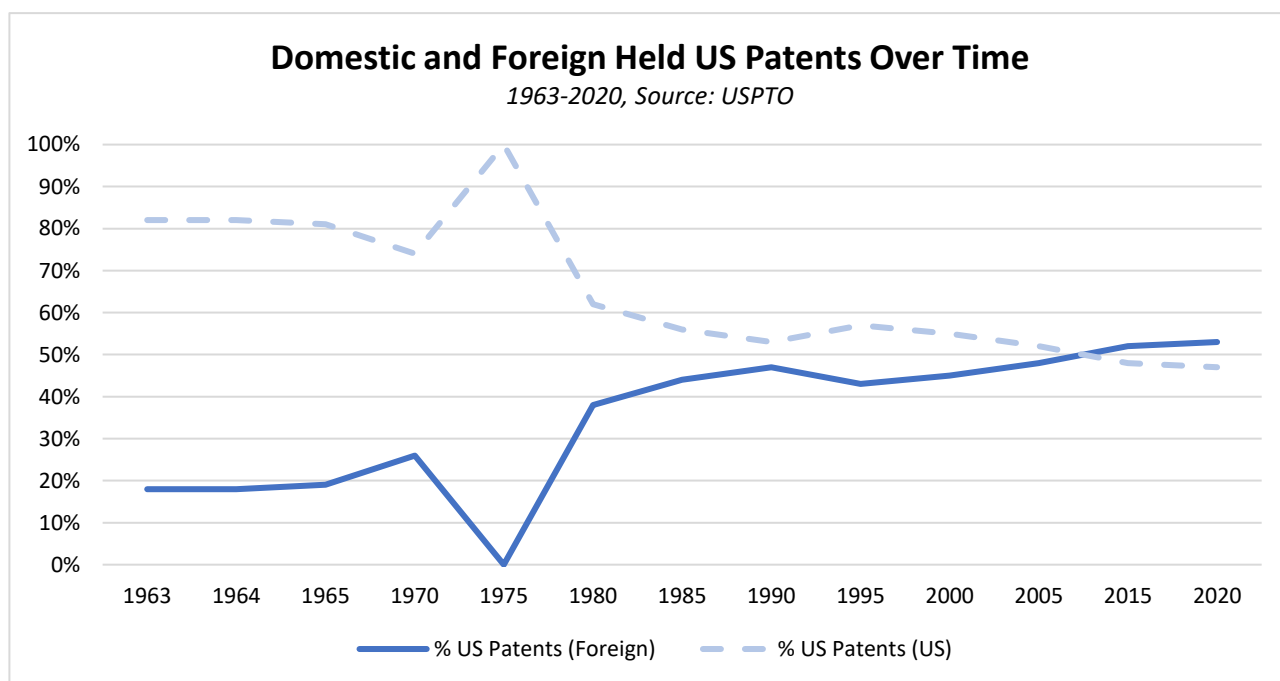
Figure 7. Domestic and Foreign Held US Patents Over Time

pathways for its participants? With the inclusion of more NSF EPSCoR ambassadors across directorates, and in other agency collaboration conversations, the administration of such programs could be better leveraged for positive outcomes.

To shift the program from "Establish" to "Empower," more resources in total research funding must be accessible. As shown in Figure 7, it has been more than a decade that most U.S.

patents are held by companies outside of the U.S. (United States Patent and Trademark Office [USPTO] 2021). Increasing funding amounts, expanding awards to include items that support the foundational contributions for an economic development hub identified above, and providing creative pathways for concerted funding for capacity generation, enablement, and then excellence will return the U.S. to being a leader in science, technology, and research and development.

7. APPENDICES

Appendix A. TABLE 2. EPSCoR Making a Difference: Evidence in Support of Investment Strategies by Programmatic Goals

Appendix B. Committee Activities and Methods

Appendix C. Document Review Resources

Appendix D. Public Comments Summary

Appendix E. Listening Session Discussion Guides

Appendix F. Listening Session Summary

Appendix G. Accessibility Captions

Appendix H. References

APPENDIX A: TABLE 2. EPSCOR MAKING A DIFFERENCE: EVIDENCE IN SUPPORT OF INVESTMENT IN PROGRAMMATIC GOALS

NSF EPSCoR Key Accomplishments, Overall, Jurisdictional and Grantee Levels, RII Track-1 2017-2021		
EPSCoR Goal 1: Catalyze Research Capability Across and Among Jurisdictions		
Overall Numbers (2017-2021)	*Exemplar Jurisdictions (2021)*	*Highlights – Grantees [6] (2017-2021)*
• Over 7,000 Researchers Supported • 16,800 Students Supported	**Researchers Supported** • South Dakota • Montana • Rhode Island **Students Supported** • Delaware • West Virginia • Arkansas • Nevada	***South Dakota Board of Regents, "Building on the 2020 Vision: Expanding Research, Education, and Innovation in South Dakota," Award No. 1849206*** **Project Summary** This project focuses on the development of a virtual, transdisciplinary, multi-institutional research collaboration center to develop next-generation, nanoscale, conformal, two-dimensional (2D) coatings with agricultural, industrial, and commercial applications. One such application is to allow agricultural crops to thrive on less fertilizer by leveraging nitrogen-fixing bacteria that can supplement nitrogen to crops. Bacterial biofilms (layers of bacteria that adhere to surfaces) are becoming increasingly valued for their potential ability to give advantageous properties to the surfaces they adhere to. To leverage this, South Dakota EPSCoR brought together faculty, staff, and students from eleven South Dakota institutions to form a new research center called the South Dakota Biofilm Science and Engineering Center (SDBSEC) under the common goal of becoming nationally recognized for developing next-generation biofilm technologies.

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[6] In this section we highlight grant activities of grantees related to the accomplishment of the specific NSF EPSCoR goal in the section. For instance, the two projects are highlighted for the various ways researchers and students were supported through the awards respectively. Only Track-1 investments are highlighted due to space limitations.

Example of Researchers and Students Supported

An example of a project activity that supported researchers and students through workshop and networking activities is the virtual NSF EPSCoR Workshop entitled "EPS-WO Gateway for Education, Training, Broader Impacts and Outreach" which was conducted in December 2020 and January 2021.

- The workshop provided infrastructure for researchers, educators, students, project managers, and the public to access, create, and share information about broader impact activities and resources.
- Over 100 participants from 19 EPSCoR jurisdictions participated in the workshop along with 8 national broader impact organizations.
- This workshop resulted in three additional workshops to continue the work on enhancing broader impact activities in EPSCoR jurisdictions.

University of Delaware, "Water Security in Delaware's Changing Coastal Environment," Award No. 1757353

Project Summary

This project addresses the major threats to Delaware's water quality and develop technical and policy solutions for meeting the challenges imposed by them. The project's partner institutions – the University of Delaware, Delaware State University, Delaware Technical Community College, and Wesley College-formed a jurisdictional network of people, institutions, data, and technologies directed at enhancing water security for human, economic, and ecosystem health. The research is focused on increasing scientific knowledge of salinization mechanisms, salinity effects on nutrient mobility, modes of transport of nutrients across coastal watersheds, and the resulting biogeochemical impacts and ecological stresses. The social dimensions thrust's outputs include early warning systems, decision-support tools, engagement of

		stakeholders and partners, and information for the development of evidence-based policies and programs. **Example of Support to Students:** An example of how the project supported students is discussed in the project activities below. - The workforce development plan involves more than 62 individual faculty and professionals and funding for up to 30 postdocs, 104 graduate students, 544 undergraduate students in internships, and 30 high school students. - Students are active participants in managing water security threats, solutions, and core research, with mentoring by faculty and postdocs and more senior students, as well as government and industry partners. - Students engaged in classroom and team research projects, laboratory support, and citizen science.
EPSCoR Goal 2: Broaden the Participation of Diverse Groups/Institutions in STEM		
Overall Numbers (2017-2021)	*Exemplar Jurisdictions (2021)*	*Highlights – Grantees (2017-2021)*
486 Underrepresented Graduate and Undergraduate Students involved in EPSCoR projects attained degrees	**Underrepresented Undergraduates and Graduates Obtaining Degrees** - Puerto Rico - Kansas - Idaho	*University of Kansas, "Microbiomes of Aquatic, Plant, and Soil Systems across Kansas," "Award No. 1656006* **Project Summary** The *Microbiomes of Aquatic, Plant, and Soil Systems across Kansas* project is synergistic with the 2016 White House Initiative to improve understanding of microbiomes. Major project goals include predicting ecosystem responses to changes in precipitation and land-use patterns and identifying ways to select for and utilize microbiomes to produce desired characteristics such as increased agricultural productivity or drought tolerance, efficient nutrient utilization, and enhanced soil

	Collaborations with HBCUs, TCUs, PUIs and HSIs • New Mexico • Vermont • South Carolina • Wyoming	quality. Through collective efforts, the project team integrates its research and educational activities to improve STEM education capacity in both urban and rural areas, among mainstream, economically-disadvantaged, and first-generation college students, Furthermore, efforts are focusing on enhancing the participation of Native Americans and other under-represented groups, and expanding the workforce in microbial, plant, and soil science, genomics, bioinformatics, and ecology. **Example of Support to Underrepresented Undergraduates in Obtaining Degrees in STEM:** An example of how the project supported underrepresented undergraduates in obtaining degrees in STEM is discussed below. • The Haskell Environmental Research Studies Institute (HERS) is an 8-week summer research program led by faculty from Haskell Indian Nations University and the University of Kansas. The program prepares Native American undergraduate students for scientific and technical careers. • Participants conducted research on climate and environmental change occurring in a Native community of their choice. • Interns presented their work at professional meetings, workshops, and symposia around the country, including the Society for Advancing Chicanos & Native Americans in Science (SACNAS) or American Indian Science and Engineering Society (AISES).

The University of Vermont and the State Agricultural College," Lake Champlain Basin Resilience to Extreme Events," Award No. 1556770

Project Summary
Seven academic institutions within Vermont leveraged existing and new investments in technology, computational resources, and human resources toward developing predictive and decision-making tools for improving drinking-water quality and protecting natural and human infrastructure in the face of increasing extreme weather events. The physical, biological, and social scientists and engineers collaborate in interdisciplinary teams to understand and model the Lake Champlain basin as a complex hydro-ecological-social system. The research team uses a systems-based, highly integrated approach to determine when and where impacts of extreme events cascaded through the combined social-ecological system.

Example of Collaboration with Multiple EPSCoR Jurisdictions
An example of engagement activities that involved collaborations with multiple EPSCoR jurisdictions to support underrepresented undergraduates is discussed in project activities below.

- For the second consecutive year, Center for Workforce Development and Diversity (CWDD) Coordinator Dr. Veronica Sosa-Gonzalez led a collaboration of three EPSCoR jurisdictions (Vermont, Delaware, and New Mexico) during the annual meeting of the Society for the Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS) from October 19, through October 24, 2020.
- In 2021, the SACNAS Conference was held remotely during which Dr. Sosa-Gonzalez distributed recruitment materials.

EPSCoR Goal 3: Establish Sustainable STEM Education, Training, & Professional Development Pathways		
Overall Numbers (2017-2021)	*Exemplar Jurisdictions (2021)*	*Highlights– Grantees (2017-2021)*
• Co-funded 210 CAREER awards (Faculty Early Career Development Awards)	**New Faculty Hired** • New Hampshire • Louisiana • Alaska	**Louisiana Board of Regents, "Louisiana Materials Design Alliance (LAMDA)," Award No. 1946231** **Project Summary** The Louisiana Materials Design Alliance (LAMDA) worked collectively to bring together several of Louisiana's public and private academic institutions to generate fundamental insights into the complex relationships among composition, processing, microstructure, performance, and structural integrity within the context of additive manufacturing. The LAMDA project brought new collaborations among participating institutions and established new partnerships with federal agencies and industries that built sustainable research and education programs in Louisiana focused on additive manufacturing. LAMDA is contributing to the growth of the Louisiana STEM workforce with a series of activities including extended/reverse research experiences for undergraduates, professional development for undergraduate and graduate students and post-doctoral fellows, course module development for undergraduate and graduate education, hiring and mentoring of new faculty, and training for community college educators. **Example of Faculty Hired through Project:** An example of how faculty were hired to support multiple academic departments across universities is discussed in project activities below. • The LAMDA team has made eight new hires in the first two years of the grant. Among them, LAMDA reported in 2021 annual report that four new hires

		included one new faculty in the Department of Computer Science at Tulane University and one new hire in Mechanical Engineering at Southern University and A & M College. There were five new hires at Louisiana State University (LSU): two in Chemistry, one Faculty in Mechanical Engineering, one in Chemistry and one in Computer Science and Engineering (Hao Wang) were hired at LSU. An additional faculty will join LSU in Fall 2022. • Two new faculty positions have been approved for the Southern University and A & M College (SUBR) team and they are the process of reviewing applications to hire new faculty. The SUBR team anticipates completing the search and making offers by May 2022.
EPSCoR Goal 4: Affect Engagement in STEM at the National and Global Levels		
Overall Numbers (2017-2021)	*Exemplar Jurisdictions (2021)*	*Highlights– Grantees (2017-2021)*
• Engaged over 9,800 Faculty in academic Institutions • Included more than 18,000 K-12 Teachers • Worked with Over 309,000 K-12 Students	**Faculty Engagement at Academic Institutions** • Hawaii • Idaho • Guam • North Dakota **K-12, Teachers and Students Engaged** • New Mexico • Mississippi • Maine • Oklahoma	*University of Hawaii System, "Ike Wai: Securing Hawaii's Water Future," Award No. 1557349* **Project Summary** 'Ike Wai: Securing Hawaii's Water Future is focused on generating more accurate and detailed models of Hawaii's aquifers, water flow, and transport processes to ensure a continued high-quality supply for Hawaii's cities, farms, and industries to address the critical needs of the state to maintain its supply of clean water, most of which comes from groundwater sources. The researchers established the Integrated Knowledge Environment, a centralized cyberinfrastructure platform for data storage, high performance computation, numerical modeling, and visualization. Trainings in geophysics, hydrology, and data science are provided to undergraduates, graduate students, and postdoctoral students.

Example of Faculty Engaged through Project

An example of faculty engagement in culturally responsive practices is discussed in project activities below.

- Nine online workshops offered to 'Ike Wai Graduate Students, postdoctoral, faculty and staff
- Extensive cultural training provided. External facilitators Ku'ulei Kanahele and Ulu Keali'ikanaka'oleohaililani from the Edith Kanaka'ole Foundation conducted a 3-hour workshop on Papakū Makawalu (October 2020), a Hawaiian worldview of the physical, intellectual, and spiritual foundations from which life cycles emerge.
- An All-Hands meeting dedicated to training in cultural values and community engagement – including Kulana Noi'i, ethical guidelines for conducting research in Hawaii in partnership with communities.
- A Hawaiian language guide with common Hawaiian words, phrases, and place names relevant to the project was created and incorporated into the project's Community Engagement Packet for internal use.
- The 'Ike Wai mentoring cascade expanded to include faculty as mentees. Six faculty are now paired with a tenured faculty from the 'Ike Wai project team.

Mississippi State University, "Mississippi EPSCoR: Center for Emergent Molecular Optoelectronics (CEMOs)," Award No. 1757220

Project Summary

Through a newly formed interdisciplinary material research Center for Emerging Molecular Optoelectronics (CEMOs), the research team shared resources and leveraged partnerships among Mississippi institutions of higher learning, national

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laboratories, and industry as well as established national and international collaborations that strengthened the research capacity to focus on building and training an inclusive workforce in optoelectronics. The research includes the development of new materials and systems that have unique electronic, and optical properties for science and engineering challenges such as sustainable energy, electronics, and biomedicine. The Center's collaborative efforts in education, outreach, and workforce development serves to support the development of a qualified STEM workforce in Mississippi, including new faculty hires and student engagement that increases diversity at all levels.

Example of K12 Students and Teachers Engaged
An example of engagement activities in which K12 teachers and students, especially those from traditionally underrepresented groups, benefited from project activities is discussed below.

- The project resulted in collaborations with K-12 schools serving traditionally underrepresented groups of students and HBCUs, providing teacher workshops, outreach events, and summer research programs at all CEMOs institutions.
- Numerous CEMOs faculty and students were involved in outreach events involving area K-12 students in year 3. Over 200 students participated in the "What is a Polymer" virtual field trips at the University of Southern Mississippi (47% underrepresented student participants).
- Polymer science students from Petal High School and Hattiesburg High School, as well as multiple middle and elementary school classes, attended the virtual field trips.

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		• Over 87% of the attendees at the Virtual Summer *Institute Machine Learning Training Event* at Jackson State University were from underrepresented groups.
EPSCoR Goal 5: Impact Jurisdictional Economic Development		
Overall Numbers (2017-2021)	*Exemplar Jurisdictions (2021)*	*Highlights– Grantees (2017-2021)*
• 64 New Patents • Leveraged Over $1.4 billion in New Awards	**Patents Awarded** • South Carolina • Kentucky • New Hampshire **Proposals/Contracts Awarded** • South Carolina • Nebraska • Alaska • Virgin Islands **Publications Supported** • New Mexico • Rhode Island • Alabama	**University of New Hampshire, "New Hampshire Center for Multiscale Modeling and Manufacturing of Biomaterials (NH Bio-Made)," Award No. 1757371** **Project Summary:** The New Hampshire Center for Multiscale Modeling and Manufacturing of Biomaterials (NH Bio-Made) focuses on creating new knowledge, driving technological innovation, and training workforce in the areas of biotechnology and advanced manufacturing. The research activities are organized around an integrated design approach that connects computational modeling, advanced manufacturing, and measurement of materials properties, all oriented toward developing new materials for biomedical applications such as orthopedic bearings and tissue engineering scaffolds. NH Bio-Made established a shared Biomaterials Core Facility that provides access to state-of the-art instrumentation and cyberinfrastructure for researchers statewide and supports the hiring of new faculty researchers at institutions across the state. **Example of New Patent Applications Related to Project** Accomplishments related to patent applications are discussed below.

- The University of New Hampshire listed 10 patent applications with two having submitted status, one granted, and 7 pending at the time of submission of its annual project report to the EPSCoR office in June of 2021.
- A patent granted from this project is "Mechanically interlocked molecules-based materials for 3-D printing, issued on March 23rd, 2021.
- A few pending patents include: "Angular Processing of Polymer Composites for Electrically Conducting Polymers," submitted June 27th, 2019, and "Conductive Bimetallic Metal-Organic Frameworks for Ultra-Sensitive Low-Power Chemical Sensing," submitted August 17th, 2018.

University of South Carolina at Columbia, "Materials Assembly and Design Excellence in South Carolina: MADE in SC," Award No. 1655740

Project Summary
The initiative for Materials Assembly and Design Excellence in South Carolina (MADE in SC) promises to break new ground in advanced materials design. The project advances fundamental knowledge of complex materials while simultaneously working toward the development of products with valuable commercial applications, such as improved lasers, water treatment, and regenerative medicine. The project is focused on making major investments in South Carolina's research capacity, acquiring state-of-the art instrumentation and computing capabilities, and hiring seventeen new faculty researchers at institutions across the state. In parallel with its research agenda, MADE in SC works to improve STEM education capacity in South Carolina through college curriculum improvements and professional development activities for high school teachers.

Example of Proposals and Contracts Awarded Related to the Project
Project accomplishments related to proposal activity are discussed below.

- Faculty members participating in this project submitted 149 research proposals with requests exceeding $96M of which 42 have been awarded with about $8M in funding and $69M in pending requests. Since the project started, MADE in SC faculty have contributed at a high level to secure over $30 Million in additional funding including 4 NSF RUI awards to faculty at PUIs.

University of New Mexico, "The New Mexico SMART Grid Center: Sustainable, Modular, Adaptive, Resilient, and Transactive," Award No. 1757207

Project Summary
The New Mexico Sustainable, Modular, Adaptive, Resilient, and Transactive (SMART) Grid Center is an interdisciplinary research center to address the power, communication, and control needs of the electrical distribution network. The New Mexico SMART Grid Center transforms the existing electricity distribution infrastructure by holistically incorporating microgrid optimization, operations optimization, microgrid controls, and tariff and customer behavior in the design and demonstration of interconnected Distribution Feeder Microgrids (DFMs). The SMART Grid Center developed new technologies, protocols, models, and algorithms for the future electric grid that can be broadly applied to future socio-cyber-physical systems, the Internet-of-Things, smart cities research and deployments, big data applications, and coordination in multi-agent systems.

Example of Publications and Conference Papers Produced Related to the Project
Publication and conference papers related to the project are discussed below.

- The project has resulted in 120+ journal publications and conference papers, ranging from "A Situation-Aware Scheme for Efficient Device Authentication in

		Smart Grid" to "How to Get Your Feet Wet in Public Engagement: Perspectives from Freshwater Scientists." • One publication with practical applications for technology use is "Enhancing the Security of Pattern Unlock with Surface EMG-Based Biometrics" by Qingqing Li, Penghui Dong and Jun Zheng published in June of 2020 in *Applied Science*. This paper examines increased security of pattern unlock, a popular screen unlock scheme that protects the sensitive data and information stored in mobile devices from unauthorized access, but which is vulnerable to various cyber-attacks. In the paper, the authors propose a new two-factor screen unlock scheme that incorporates surface electromyography (sEMG)-based biometrics with patterns for user authentication. The results of testing the proposed technology demonstrate that the proposed scheme is a promising solution to enhance the security of pattern unlock.

APPENDIX B: COMMITTEE ACTIVITIES AND METHODS

As part of its effort to gather broad input, the Committee conducted several data gathering activities between May and December 2021 that helped inform its recommendations.

Document review. The Committee engaged in a review of documents pertaining to NSF EPSCoR to provide context to the current visioning activity and inform their recommendations. Documents reviewed for this activity included reports from past visioning activities, NSF EPSCoR strategic documents and evaluation reports, Committee of Visitors reports, Congressional reports, and NSF and NSB strategic visioning reports. A complete list of documents provided to the Committee for review is included in Appendix C.

Public comment request. The Committee launched a request for public comments on the NSF website to gather input on the EPSCoR program. The comment request was open to anyone interested in providing input on EPSCoR and was widely publicized across the EPSCoR stakeholder community. The public comment request included three prompts asking for feedback on EPSCoR, and remained opened between September 9, 2021, and November 1, 2021 (see Appendix D). At the close of the submission period, the Committee had received 49 unique responses. Responses were systematically analyzed for themes and patterns by a team of researchers using qualitative data analysis software and shared with the Committee to inform the recommendations of this report.

Listening sessions. Committee members facilitated six virtual listening sessions targeted at a diverse group of EPSCoR stakeholders, each lasting 120 minutes, with approximately 30 participants for each session. Stakeholder groups invited as part of these listening sessions included: 1) NSF EPSCoR Track-1 PIs; 2) NSF EPSCoR Track 2, Track 4, and other NSF PIs; 3) MSI/ PUI administrators and faculty; 4) the broader EPSCoR community (state committees; Economic Development Councils (EDCs); industry); 5) scholars and evaluators in academic research competitiveness; and 6) university administrators (Chairs, Deans, Velocity Prediction Rating System (VPRS). For each listening session, the Committee developed a moderator's guide containing questions specific to each group and aimed at informing the two guiding questions of the visioning activity (see Appendix E). These sessions were conducted using a video conferencing platform, and subsequently transcribed and analyzed by a team of researchers who shared the results with the Committee.

Ad-hoc analyses. In addition to the above data gathering activities, the Committee was supported by a team of NSF program analysts who engaged in a series of ad-hoc analyses using data on the NSF EPSCoR program that helped inform this report's recommendations.

APPENDIX C: DOCUMENT REVIEW RESOURCES

Program Solicitations

EPSCoR Research Infrastructure Improvement Program Track-1 (RII Track-1) (NSF 22-599)
EPSCoR Research Infrastructure Improvement Program: Track-2 Focused EPSCoR Collaborations (RII Track-2 FEC) (NSF 22-523)
EPSCoR Research Infrastructure Improvement (RII) Track-4: EPSCoR Research Fellows (NSF 22-573)
Established Program to Stimulate Competitive Research: Workshop Opportunities (EPS-WO) (19-588)

Program Eligibility

EPSCoR FY2022 Jurisdictional Eligibility Data
Current EPSCoR Eligibility Methodology
2019 EPSCoR Eligibility Review Slides

Jurisdictional Fact Sheets

Jurisdictional Fact Sheets

2020 Committee of Visitors Report and Response

EPSCoR 2020 Committee of Visitors Report
EPSCoR Response to Findings and Recommendations of the 2020 Committee of Visitors Report

2020 NSF and NSB Strategic Visioning Documents

NSB Vision 2030
Building the Future Investing in Discovery and Innovation: NSF Strategic Plan for Fiscal Years (FY) 2018-2022
NSF Evaluation Plan for FY 2022

Prior EPSCoR External Visioning Activities

EPSCoR 2020: Expanding State Participation in Research in the 21st Century -- A New Vision for the Experimental Program to Stimulate Competitive Research (EPSCoR)
EPSCoR 2030: A Report to the National Science Foundation

APPENDIX D: PUBLIC COMMENTS SUMMARY

The Committee on the Future of NSF EPSCoR received comments from the public on NSF EPSCoR from September 9th, 2021, to November 1st, 2021. Forty-nine unique respondents responded to at least one of the three separate prompts posted on the Future of NSF EPSCoR website. The prompts are listed below:

- What current NSF EPSCoR investment strategies have you found to be successful? What makes them successful? Please give examples of these successes, particularly for how NSF EPSCoR investments have led to sustained improvements to research competitiveness for individuals, teams, institutions, or jurisdictions.

- What factors influence the effectiveness of NSF EPSCoR investments? How are you measuring their effectiveness and/or success?

- Are there additional strategies or investment areas that could help NSF EPSCoR and its jurisdictional partners achieve their shared goals? What competitiveness gaps might such strategies address, and how might they work? Cite evidence where possible to support your ideas.

Trewon analyzed the public comment data in NVivo qualitative analysis software using a broad set of descriptive coding categories aligned with focus areas in the report outline developed by the Committee: General Recommendations, Research and Infrastructure, Broadening Participation, Education and Workforce Development, and Economic Development. Within each of these areas, Trewon summarized successes and additional strategies associated with each category. An overall recommendations section addressed cross-cutting topics related to facilitating factors, metrics of success, and caveats to program success. Table 3 below summarizes respondents' institution type.

TABLE 3. Classification of Public Comment Respondents' Institutional Affiliations

Type	Count	Percentage
Doctoral Universities: Very High Research Activity	14	34.1%
Doctoral Universities: High Research Activity	9	22.0%
Master's Colleges & Universities: Larger Programs	1	2.4%
Master's Colleges & Universities: Smaller Programs	1	2.4%
Baccalaureate Colleges: Arts and Sciences	1	2.4%
NSF EPSCoR State Office	10	24.4%
Other*	2	4.9%
Not Reported	3	7.3%
Total	**41**	**100.00%**

Other includes non-academic institutions such as private institutions. Public comment respondents also had the option to remain anonymous and those that did not provide their institutional affiliation are included in the category of Not Reported.

General Recommendations

More than half of respondents (28 of 49 respondents, 57%) suggested at least one way to improve NSF EPSCoR overall. Seventeen respondents (34.7%) offered suggestions related to eligibility and administration of the grants such as reducing the red tape involved in grant administration (3, 6.1%), changing jurisdictional eligibility to better align with NSF EPSCoR goals (3, 6.1%)[7], and making the NSF EPSCoR awards renewable (2, 4.1%). Ten (20.4%) respondents recommended changing the funding structure (for example, more funding and longer funding cycles).

Twenty of the 49 respondents (40.8%) identified factors that they associated with the effectiveness and success of NSF EPSCoR. The facilitating factors most often identified by respondents are the co-funding mechanism (7, 14.2%), an institutional commitment to funding (4, 8.2%), jurisdictional awards in contrast to individual grants (3, 6.1%), the existing level of institutional support (3, 6.1%), Principal Investigator (PI) grants (2, 4.1%), and the visibility of the program (2, 4.1%). Fourteen of the 49 respondents (28.6%) listed metrics that they and their institutions use to measure the success of NSF EPSCoR. The metrics most often identified by respondents include number of publications (8, 16.3%); additional funding (5, 10.2%); number of undergraduate, graduate, and post-doctoral students trained (3, 6.1%); research capacity and production improvements (2, 4.1%); number of proposals funded by NSF EPSCoR (2, 4.1%); faculty hired and retained (2, 4.1%); and number of degrees granted (2, 4.1%). Eight of the 49 respondents (16.3%) identified caveats to NSF EPSCoR's success. Such caveats include that the program has been unsuccessful or only partially successful, that the program tends to award the same groups of researchers, that the science that was funded could have occurred anyway, and that the general political climate of COVID-19 has made the environment difficult for scientists in general.

Themes by Working Group

Beyond cross-cutting themes related to general recommendations, Trewon disaggregated the data as it related to the four areas addressed by the Committee working groups: 1) Research and Infrastructure; 2) Education and Workforce Development, 3) Broadening Participation, and 4) Economic Development.

Research and Infrastructure

Respondents most frequently discussed successes and suggestions related to the area of research and infrastructure. Thirty-three respondents (67.3%) either identified successes related to improvements in research and infrastructure associated with the program and/or discussed additional strategies to improve research and infrastructure outcomes associated with the program. Twenty-five respondents (51.0%) identified one of two types of successes related to research and infrastructure: twenty-two respondents (44.9%) discussed increased research and infrastructure capacity, and ten respondents (20.4%) discussed increased institutional connections and collaborations. Respondents discussed increased faculty hiring and professional development physical and computing infrastructure, additional grants, sustained research programs, support for centers, institutes, and research clusters. Nineteen of the 49 respondents (38.8%) provided suggestions for additional strategies related to improving research and infrastructure outcomes of the program. Suggestions for improving research and infrastructure discussed by no more than one respondent included increasing the pool of talented graduate students to attract faculty, support for small to mid-sized equipment, support for less established faculty to develop new research areas for the state and instituting incentive programs for faculty mentoring.

Education and Workforce Development

Eighteen of the 49 respondents (36.7%) discussed either the successes of NSF EPSCoR in improving education and workforce development outcomes or offered strategies to help improve outcomes in this area: 13 respondents (26.5%) discussed successes while 9 respondents (18.4%) discussed strategies. Respondents identified STEM education and opportunities for student and funding to hire undergraduates, graduate students, and post-doctoral students. Seven of the 49 respondents (14.3%) offered suggestions on how to improve education and workforce development outcomes for NSF EPSCoR. These suggestions include creating a track focused on workforce development, valuing cross-over talent from industry experts, and supporting additional workforce educational programs.

Broadening Participation

Thirteen of the 49 respondents (26.5%) discussed broadening participation either as a success of NSF EPSCoR or provided additional feedback on how the program could achieve better outcomes with respect to underrepresented groups. Respondents identified supporting diverse faculty, students, and communities, funding the hiring of diverse faculty, particularly the recruitment and retention of underrepresented and female faculty. Eleven respondents (22.4%) made suggestions related to broadening participation to improve the program. These include providing more support to hire diverse faculty and more funding and decision-making to PUI's, HBCUs and tribal colleges.

Economic Development

Eight of 49 respondents (16.3%) either discussed how NSF EPSCoR contributed to economic development in jurisdictions or offered additional strategies for how to improve economic development because of the program: four respondents (8.2%) discussed support of industries in jurisdictions as a success of the program, while four respondents (8.2%) offered suggestion on improving outcomes for economic development related to the program. Respondents discussed the support of jurisdictions' economic development, the creation of startups, providing seed grant funding and facilitating commercial applications as successes of the program related to improved economic development. Respondents suggested strategies to reduce the competitiveness gap between NSF EPSCoR states and non-NSF EPSCoR states and the competitiveness gap between RI's and PUIs, supporting academic-industry collaborations, and the addition of a track focused on the development of a start-up company.

APPENDIX E: LISTENING SESSION DISCUSSION GUIDES

Listening Session 1: Track-1
Discussion Guide for NSF EPSCoR

Reminders
- Participants may express agreement with each other's opinions, but co-leads should be careful not to lead participants toward consensus.
- The co-lead role is intended to elicit ideas from stakeholders rather than to share your own ideas.
- There is limited time to hear from all participants, so be judicious when asking follow-up questions.

Schedule of Activities

Introduction
[10 minutes: 5 minutes introduction and 5 minutes questions]

- Thank you for participating in today's Future of NSF EPSCoR listening session, which focuses on Track-1 projects.
- My name is Kimberley Raue, the Director of Research and Evaluation at Trewon Technologies, an organization supporting NSF EPSCoR's year-long visioning process. The purpose of these listening sessions is to talk with EPSCoR's external stakeholder community to better understand the impacts of EPSCoR investment strategies and identify new opportunities for increased success.
- NSF is genuinely interested in hearing your experiences with and opinions about EPSCoR. There are no right or wrong answers to the questions we will be asking you today.
- To ensure we capture your responses accurately, we will be recording today's session.
- [BEGIN RECORDING]
- We will ask you to respond to a few broad questions. Please raise your hand if you'd like to respond to a question or add your comments to the chat.
- Given time constraints and the interest we have in hearing from as many of you as possible, we may step in on occasion to open the discussion up to other participants or move to the next topic.
- I'd now like to introduce Marian McCord, Senior Vice Provost for Research, Economic Engagement, and Outreach at the University of New Hampshire and Prakash Nagarkatti, Senior Research Advisor to the President and Carolina Distinguished Professor at the University of South Carolina who will lead the discussion.

Questions
[105 minutes: 35 minutes per topic]

Topic 1: Innovation in Research
[35 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- The first topic we'd like to talk about is innovation.
- To what extent does the EPSCoR Track-1 program allow jurisdictions to push the boundaries of innovation in research?

Topic 2: Program and Jurisdictional Effectiveness
[35 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- Now we'd like to talk about the factors that influence the effectiveness and capacity of your EPSCoR programs and jurisdictions.
- What factors would you say contribute to or impede the effectiveness of your EPSCoR programs?
- What are some areas for which additional EPSCoR investments could have a significant impact on overall jurisdictional effectiveness and capacity?

Topic 3: Institutional Diversity
[35 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- Finally, we'd like to talk about institutional diversity within the EPSCoR program.
- To what extent do EPSCoR investments support institutions with differing missions (PUIs, MSIs, TCUs, community, and technical colleges)?
- What are some new ways in which NSF can facilitate the support it provides these institutions?

Additional Questions, Time Permitting

- How are you benchmarking success or effectiveness of EPSCoR investments?
- How have EPSCoR investments helped build the jurisdictional infrastructure necessary for national-level competitiveness?
- How have the EPSCoR investments helped train undergraduates, graduate students, PhDs in research?
  - Are there any additional opportunities needed to enhance this endeavor?
- How have the current EPSCoR programs engaged industry in your jurisdiction?
  - Are there new ways to promote such collaborations?
- To what extent is state support effective in supporting EPSCoR investments?

- Track-1 has multiple priorities. How would you weigh these priorities based on your experience in your jurisdiction?

Closing
[5 minutes]

- Thank you so much for sharing your thoughts and experiences on NSF EPSCoR with us! The lessons learned from today will be incredibly valuable to NSF and the NSF EPSCoR visioning process.
- We encourage you to extend the discussion from today by visiting the Future of NSF EPSCoR website and responding to the public comment request.
- [POST WEBSITE IN CHAT]: https://beta.nsf.gov/envisioning-future-nsf-epscor/epscor-public-comment]

Listening Session 2: Other NSF PIs in EPSCoR (including Track-2 and Track-4 PIs)
Discussion Guide for NSF EPSCoR

Reminders

- Participants may express agreement with each other's opinions, but co-leads should be careful not to lead participants toward consensus.
- The co-lead role is intended to elicit ideas from stakeholders rather than to share your own ideas.
- There is limited time to hear from all participants, so be judicious when asking follow-up questions.

Schedule of Activities

Introduction
[10 minutes: 5 minutes introduction and 5 minutes questions]

- Thank you for participating in today's Future of NSF EPSCoR listening session, which focuses on Track-2 and Track-4 projects.
- My name is Kelly Rusch, and I am an Associate Chair and Professor in the Department of Civil, Construction, and Environmental Engineering at North Dakota State University and the Executive Director of the North Dakota EPSCoR State Office. I am also a Co-chair for the Committee on the Future of NSF EPSCoR, supporting NSF in their year-long visioning process for the NSF EPSCoR program.
- The purpose of these listening sessions is to talk with EPSCoR's external stakeholder community to better understand the impacts of EPSCoR investment strategies and identify new opportunities for increased success.
- NSF is genuinely interested in hearing your experiences with and opinions about EPSCoR. There are no right or wrong answers to the questions we will be asking you today.
- To ensure we capture your responses accurately, we will be recording today's session.
- [BEGIN RECORDING]
- We will ask you to respond to a few broad questions. Please raise your hand if you'd like to respond to a question or add your comments to the chat.
- Given time constraints and the interest we have in hearing from as many of you as possible, we may step in on occasion to open the discussion up to other participants or move to the next topic.
  I'd now like to introduce Prabhakar Clement, Director of the Center for Water Quality Research and

Professor of Environmental Engineering at the University of Alabama and Michael Khonsari, Dow Chemical Endowed Chair and Professor of Mechanical Engineering at Louisiana State University. They will lead today's discussion.

Questions
[105 minutes: 21 minutes per topic]

Note: We are interested in hearing your novel ideas to improve the EPSCoR program (<u>not</u> how it should be implemented)

Topic 1: General Feedback on the Program
[21 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- The EPSCoR program is intended to provide a foundation for your research career.
- How well do you think it has done that?
- What is it about being involved in EPSCoR that has been most important for your career (and your research?)
- Based on your personal experience or what you have observed on your team, how do you think it has made a difference for early-career researchers?
- Suggest how to improve the program.

Topic 2: Thinking Outside the Box
[21 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- Assume that you were to redesign the EPSCoR program and/or its funding mechanisms; what suggestions can you offer that would significantly elevate the research capacity and competitiveness of EPSCoR jurisdictions.
  - This could be within the tracks that you are participating in or even beyond. Can you envision new generations of tracks? Assume resources are available.

Topic 3: Statewide Collaborative Research
[21 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- How could EPSCoR projects be structured to enhance collaboration across institutions?
  - Are there any challenges that you can identify in these types of collaborations?
- How could EPSCoR investments more effectively promote entrepreneurship and industry collaboration?

Topic 4: MSI/TCU/PUI Collaboration
[21 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- Explain how well MSI/TCU/PUI collaborations are being accomplished?
- How can NSF assist in building and enhancing these collaborations?

Topic 5: Cross-Jurisdictional Collaboration (Track-2)
[21 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- What are some of the ways that <u>cross-jurisdictional</u> collaboration can lead to nationally competitive and sustainable research programs?
  - Suggest unique or specific ideas for Track-2 awards that you think make a difference in building research collaboration and related scientific discovery across jurisdictions.
  - Suggest ideas to strengthen teamwork across jurisdictions.
- What are some of the ways that NSF could create "cross-jurisdictional excellence" in specific areas to become "Go-To-Places" for strategic research themes (e.g., materials, water, cyber security, energy, manufacturing) for the entire nation?

Closing
[5 minutes]

- Thank you so much for sharing your thoughts and experiences on NSF EPSCoR with us! The lessons learned from today will be incredibly valuable to NSF and the NSF EPSCoR visioning process.
- We encourage you to extend the discussion from today by visiting the Future of NSF EPSCoR website and responding to the public comment request.
- [TREWON WILL POST WEBSITE IN CHAT]: https://beta.nsf.gov/envisioning-future-nsf-epscor/epscor-public-comment]

Listening Session 3: MSI/TCU/PUI Administrators and Faculty
Discussion Guide for NSF EPSCoR

Reminders

1. Participants may express agreement with each other's opinions, but co-leads should be careful not to lead participants toward consensus.
2. The co-lead role is intended to elicit ideas from stakeholders rather than to share your own ideas.
3. There is limited time to hear from all participants, so be judicious when asking follow-up questions.

Schedule of Activities

Introduction
[10 minutes]

- Thank you for participating in today's Future of NSF EPSCoR listening session, which focuses on MSIs, TCUs, and PUIs.
- My name is Kelly Rusch, and I am an Associate Chair and Professor in the Department of Civil, Construction, and Environmental Engineering at North Dakota State University and the Executive Director of the North Dakota EPSCoR State Office. I am also a Co-chair for the Committee on the Future of NSF EPSCoR, supporting NSF in their year-long visioning process for the EPSCoR program.
- The purpose of these listening sessions is to talk with EPSCoR's external stakeholder community to better understand the impacts of EPSCoR investment strategies and identify new opportunities for increased success.
- NSF is genuinely interested in hearing your experiences with and opinions about EPSCoR. There are no right or wrong answers to the questions we will be asking you today.
- To ensure we capture your responses accurately, we will be recording today's session.
- [BEGIN RECORDING]
- We will ask you to respond to a few broad questions. Please raise your hand if you'd like to respond to a question or add your comments to the chat.
- Given time constraints and the interest we have in hearing from as many of you as possible, we may step in on occasion to open the discussion up to other participants or move to the next topic.
- I'd now like to introduce Daniela Marghitu, Faculty Coordinator and Director of the Research Laboratory for Education and Assistive Technology in the Computer Science and Software Engineering Department at Auburn University and Scott Wicker, Interim Chair of the School of

Sciences, Technology, Engineering, and Mathematics (SoSTEM) and Associate Professor of Chemistry at Kentucky State University. They will lead today's discussion.

Questions
[105 minutes: 21 minutes per topic]

Topic 1: Cross-Institutional and Jurisdictional Collaboration
[21 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- Let's start with the general integration of your institutions in EPSCoR projects. First, we would like to talk about this WITHIN your state, and then, if you also have experience in cross-jurisdictional awards, we would also like to hear about that.
- How well are your institutions integrating with other institutions in the state? How effective are these relationships? What are the challenges you face?
  - o Probe: be sure that you address issues of research, outreach, faculty, students, but also grant administration.
- What interventions do you recommend to strengthen and enhance cross-institutional collaborations in your state/jurisdiction, especially with Community Colleges, PUIs, and MSIs such as HSIs, HBCUs, and TCUs?
- Now, if you also have experience in multi-jurisdictional (Track-2 or other) awards, we would also like to understand those experience. Would you please tell us about the effectiveness of the inter-jurisdictional collaboration at your institution?
  - o Long-term, is the current inter-jurisdictional collaboration beneficial for your institution's strategic plan?
- What interventions do you recommend to strengthen and enhance inter-jurisdictional collaborations, especially with Community Colleges, PUIs, and MSIs such as HSIs, HBCUs, and TCUs?

Topic 2: Broadening Participation
[21 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- Your institutions also present opportunities for enhancing diversity as well as broadening participation. Would you please tell us about how do you personally or your institution use EPSCoR resources to broaden participation?
- Please tell us how can EPSCoR improve on current resources to help you personally or your institution broaden participation?
- Please tell us how can EPSCoR help you personally or your institution access new resources or suggest a novel idea that will significantly improve broadening participation at your institution?

Topic 3: Research and Infrastructure Capacity

[21 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- Proper infrastructure is needed for the successful development of research and education in STEM fields. This infrastructure could be physical (e.g., labs, equipment, etc.), human resources (e.g., dedicated grants management personnel, new faculty, training and development for administrative staff), or cyberinfrastructure (enhanced computational and storage capacity, managing or operational software).
- Would you please tell us about how you personally or your institution use EPSCoR current investments for research and infrastructure capacities and capabilities at your institution?
- If there are areas to improve or enhance current EPSCoR investments, please tell us about interventions that will significantly improve your institution's research and infrastructure capacities and capabilities.

Topic 4: Education and Workforce Development
[21 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- Would you please tell us about how you personally or your institution use EPSCoR current investments to provide access to quality education and workforce development opportunities at your institution?
- Tell us about how effective is EPSCoR's current investments at creating or synergizing quality educational programming and/or workforce development opportunities at your institution?
- What are challenges with EPSCoR current education and workforce development investments you personally or your institution faced?
- If there are areas to improve or enhance current EPSCoR investments, please tell us about interventions that will significantly improve education and workforce development at your institution.

Topic 5: Thinking Outside the Box
[21 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- Assume that you were to redesign the program; what suggestions can you offer that would significantly elevate the effectiveness of EPSCoR investments for your type of institution specifically. This could be within the tracks that you are participating in or even beyond. Can you envision new generations of tracks? Assume resources are available.
- Reflect on the following questions:
    o Is EPSCoR current investments inclusive of the faculty, students, and community stakeholders at your institution?
    o What can EPSCoR do to help you personally or your institution be more responsive to emerging research, markets, technologies, and STEM career opportunities? [Note: should we provide examples of emerging opportunities? End note]

- o   How could EPSCoR be more effective for promoting entrepreneurship and industry collaboration?

Note: We are interested in hearing what you would suggest. Not how it should be done.

Closing
[5 minutes]

- Thank you so much for sharing your thoughts and experiences on NSF EPSCoR with us! The lessons learned from today will be incredibly valuable to NSF and the NSF EPSCoR visioning process.
- We encourage you to extend the discussion from today by visiting the Future of NSF EPSCoR website and responding to the public comment request.
- [TREWON WILL POST WEBSITE IN CHAT]: https://beta.nsf.gov/envisioning-future-nsf-epscor/epscor-public-comment]

Listening Session 4: Broader Community (State Committees, EDC's, industry, etc.)
Discussion Guide for NSF EPSCoR

Reminders

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3. There is limited time to hear from all participants, so be judicious when asking follow-up questions.

Schedule of Activities

Introduction
[5 minutes]

- Thank you for participating in today's Future of NSF EPSCoR listening session, which focuses on the broader community of EPSCoR stakeholders, including representatives from industry, state government, and community organizations.
- My name is Kelly Rusch, and I am an Associate Chair and Professor in the Department of Civil, Construction, and Environmental Engineering at North Dakota State University and the Executive Director of the North Dakota EPSCoR State Office. I am also a Co-chair for the Committee on the Future of NSF EPSCoR, supporting NSF in their year-long visioning process for the EPSCoR program.
- The purpose of these listening sessions is to talk with EPSCoR's external stakeholder community to better understand the impacts of EPSCoR investment strategies and identify new opportunities for increased success.
- NSF is genuinely interested in hearing your experiences with and opinions about EPSCoR. There are no right or wrong answers to the questions we will be asking you today.
- To ensure we capture your responses accurately, we will be recording today's session.
- [BEGIN RECORDING]
- We will ask you to respond to a few broad questions. Please raise your hand if you'd like to respond to a question or add your comments to the chat.
- Given time constraints and the interest we have in hearing from as many of you as possible, we may step in on occasion to open the discussion up to other participants or move to the next topic.
- I'd now like to introduce Mary Jo Daniel, Associate Vice President for Research at the University of New Mexico and Carol Silva, Co-Director of the National Institute for Risk and Resilience, Director of the Center for Risk and Crisis Management, and Edith Kinney Gaylord

Presidential Professor of Political Science at the University of Oklahoma. They will lead today's discussion.

Questions
[110 minutes: ~ 18 minutes per topic; 20 minutes for the first topic]

Introduction

The people in this session have varying levels of connection to academia and NSF. We are excited to have people here from many different perspectives including industry, national labs, government, community organizations, and academics. As you answer these questions, feel free to tell us in a sentence or two about yourself and how you've been connected to an EPSCoR project. In our discussion, we're going to refer to the state or territory with which you are affiliated as a jurisdiction.

Topic 1: STEM Research Capacity and Competitiveness
[20 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- The goal of NSF EPSCoR is to build STEM research capacity and competitiveness. From your perspective, tell us how you think your jurisdiction is currently doing in terms of STEM research capacity and competitiveness.
- Do you think your jurisdiction is about average or above or below average in terms of STEM research capacity and competitiveness?
- Why do you think that?
- Do you have any ideas about how to improve STEM research capacity and competitiveness in your jurisdiction?

Topic 2: NSF INVESTMENTS
[18 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- When thinking about the role of NSF, can you identify specific kinds of investments or programs that would have a positive impact on STEM research capacity in your jurisdiction?

Topic 3: State/Territory EPSCoR Committees
[18 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- For those of you that are on State/Territory EPSCoR committees, can you tell us a little about how your state committee is organized and how effective they are at helping to build STEM capacity in your jurisdiction?
- Do you have any ideas for how NSF can help you achieve your goals for increasing capacity?

Topic 4: Partnerships

[18 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- National labs, government agencies, industry, and community groups are important and valued partners in NSF funded projects. In your experience how well do you think these partnerships have worked?
- Do you have any suggestions for how to make these partnerships work better?

Topic 5: STEM Capacity and Economic Development
[18 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- How is STEM capacity in your jurisdiction connected to growing economic development?
- What do you think is needed to grow economic opportunities in your jurisdiction?
- How can NSF help with this?

Topic 6: STEM Capacity and K-12 Education
[18 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- Within your jurisdiction how does existing STEM capacity facilitate or enhance K-12 education?
- What do you think can be done to better link STEM capacity to K-12 education in your jurisdiction?
- How can NSF help with this?

Closing
[5 minutes]

- Thank you so much for sharing your thoughts and experiences on NSF EPSCoR with us! The lessons learned from today will be incredibly valuable to NSF and the NSF EPSCoR visioning process.
- We encourage you to extend the discussion from today by visiting the Future of NSF EPSCoR website and responding to the public comment request.
- [TREWON WILL POST WEBSITE IN CHAT]: https://beta.nsf.gov/envisioning-future-nsf-epscor/epscor-public-comment]

Listening Session 5: Scholars in Academic Research Competitiveness
Discussion Guide for NSF EPSCoR

Reminders

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2. The co-lead role is intended to elicit ideas from stakeholders rather than to share your own ideas.
3. There is limited time to hear from all participants, so be judicious when asking follow-up questions.

Schedule of Activities

Introduction
[5 minutes]

- Thank you for participating in today's Future of NSF EPSCoR listening session, which focuses on the broader community of EPSCoR stakeholders, including representatives from industry, state government, and community organizations.
- My name is Kelly Rusch, and I am an Associate Chair and Professor in the Department of Civil, Construction, and Environmental Engineering at North Dakota State University and the Executive Director of the North Dakota EPSCoR State Office. I am also a Co-Chair for the Committee on the Future of NSF EPSCoR, supporting NSF in their year-long visioning process for the EPSCoR program.
- The purpose of these listening sessions is to talk with EPSCoR's external stakeholder community to better understand the impacts of EPSCoR investment strategies and identify new opportunities for increased success.
- NSF is genuinely interested in hearing your experiences with and opinions about EPSCoR. There are no right or wrong answers to the questions we will be asking you today.
- To ensure we capture your responses accurately, we will be recording today's session.
- [BEGIN RECORDING]
- We will ask you to respond to a few broad questions. Please raise your hand if you'd like to respond to a question or add your comments to the chat.
- Given time constraints and the interest we have in hearing from as many of you as possible, we may step in on occasion to open the discussion up to other participants or move to the next topic.
- I'd now like to introduce Edwin Cruz-Rivera, Associate Professor in the Department of Biological Sciences at the University of the Virgin Islands and Sheena Murphy, Associate Vice President for Research Development and Professor of Physics at West Virginia University. They will lead today's discussion.

Background of EPSCoR and Purpose of Listening Session
[5 minutes]

40 years ago, the National Science Foundation created the Established (formerly Experimental) Program to Stimulate Competitive Research (EPSCoR) in response to concern over the uneven geographic distribution of federally funded research and development grants. The EPSCoR program currently invests in 28 jurisdictions (states and territories) by means of various tracks (1, 2, and 4) and EPSCoR co-funding with awards that span from individual researchers to jurisdiction/statewide. EPSCoR is now engaged in a visioning activity that reflects on the recent past to chart a future of opportunities responding to current trends and needs for capacity building within EPSCoR jurisdictions. The Committee on the Future of EPSCoR is charged with investigating the effectiveness of this long-running program and providing recommendations for innovative new strategies and investments.

The goal of this particular listening session is to gather ideas and perspectives from experts within both EPSCoR and non-NSF EPSCoR jurisdictions that will allow us to compare and evaluate approaches for cultivating research competitiveness. The invitees include successful researchers from EPSCoR jurisdictions, evaluators of EPSCoR programs and scholars of research competitiveness. While this is an NSF committee, we are interested in hearing about programs from any agency (NIH, USDE, etc.) that have demonstrated success for enhancing and sustaining research competitiveness. We would welcome your thoughts on how those programs can be adapted to the NSF. We would also like to hear of strategies targeted at different scales, from single investigators to entire regions. We want to be cognizant of the varied approaches that might be relevant for institutions that have different resources, constituencies and missions and span the spectrum from R1 to R3, from PhD granting to community college and from PWI to MSI. And we would like for you to reflect on the myriad of different strategies from funding for research, funding for collective instrumentation, mentoring programs, sponsored program development, training, industrial engagement, release time etc.

Questions
[105 minutes: 35 minutes per topic]

Topic 1: Early Career Faculty
[35 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- Thinking specifically about early career faculty, what can be done to help support their research competitiveness?
- Can you give us examples of things that have worked well and things that have not worked so well?

- What unique needs might early career faculty in EPSCoR jurisdictions have that NSF EPSCoR could address with entirely new investments or changes to existing programs?

Topic 2: Developing and Sustaining Research Competitiveness at the Individual Investigator, Team, and Institutional Level
[35 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- What are the most effective strategies or programs that can be employed for developing and sustaining research competitiveness for individuals and collaborative teams? For institutions?
- Can you give us examples of things that have worked and those that have not worked?
- What unique needs might faculty, teams, and institutions in EPSCoR jurisdictions have that NSF EPSCoR could address with entirely new investments or changes to existing programs?

Topic 3: Jurisdiction wide and Cross Jurisdictional Support
[35 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- What are the most effective strategies or programs that can be employed for developing and sustaining research competitiveness at a jurisdictional level?
- Can you give us examples of things that have worked and those that have not worked?
- What kind of investments could NSF EPSCoR make that would make the most impact in developing and sustaining research competitiveness for an entire jurisdiction?

Closing
[5 minutes]
- Thank you so much for sharing your thoughts and experiences on NSF EPSCoR with us! The lessons learned from today will be incredibly valuable to NSF and the NSF EPSCoR visioning process.
- We encourage you to extend the discussion from today by visiting the Future of NSF EPSCoR website and responding to the public comment request.
- [TREWON WILL POST WEBSITE IN CHAT]: https://beta.nsf.gov/envisioning-future-nsf-epscor/epscor-public-comment]

Listening Session 6: University Administrators
Discussion Guide for NSF EPSCoR

Reminders

1. Participants may express agreement with each other's opinions, but co-leads should be careful not to lead participants toward consensus.
2. The co-lead role is intended to elicit ideas from stakeholders rather than to share your own ideas.
3. There is limited time to hear from all participants, so be judicious when asking follow-up questions.

Schedule of Activities

Introduction
[10 minutes]

- Thank you for participating in today's Future of NSF EPSCoR listening session, which focuses on university administrators.
- My name is Kelly Rusch, and I am an Associate Chair and Professor in the Department of Civil, Construction, and Environmental Engineering at North Dakota State University and the Executive Director of the North Dakota EPSCoR State Office. I am also a Co-chair for the Committee on the Future of NSF EPSCoR, supporting NSF in their year-long visioning process for the EPSCoR program.
- The purpose of these listening sessions is to talk with EPSCoR's external stakeholder community to better understand the impacts of EPSCoR investment strategies and identify new opportunities for increased success.
- NSF is genuinely interested in hearing your experiences with and opinions about EPSCoR. There are no right or wrong answers to the questions we will be asking you today.
- To ensure we capture your responses accurately, we will be recording today's session.
- [BEGIN RECORDING]
- We will ask you to respond to a few broad questions. Please raise your hand if you'd like to respond to a question or add your comments to the chat.
- Given time constraints and the interest we have in hearing from as many of you as possible, we may step in on occasion to open the discussion up to other participants or move to the next topic.
- I'd now like to introduce Christine Cutucache, Associate Professor of Biology at the University of Nebraska at Omaha and Susan Renoe, Associate Vice Chancellor for Research at the University of Missouri. They will lead today's discussion.

Questions

[100 minutes: 25 minutes per topic]

We want to capture your suggestions, feedback, and pain points regarding EPSCoR opportunities. Today we'll have 4 questions, one includes an open response, and the others center around research infrastructure and sustainability (to include research administration and inter-jurisdictional collaborations).

Topic 1: Investments in Research

[25 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- Would investments in research administration or infrastructure enable your jurisdiction to grow its research?

Topic 2: Promoting Entrepreneurship

[25 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- How could EPSCoR be more effective for promoting entrepreneurship and industry collaboration?

Topic 3: Long-term Effectiveness and Sustainability

[25 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- How could the long-term effectiveness of inter-jurisdictional collaboration be achieved, and how can this be made sustainable over the long term?

Topic 4: Open Ended

[25 minutes: Trewon will notify co-leads when there are 5 minutes left in each session]

- Open-ended: Tell us anything that you have not yet been able to share about EPSCoR. (Feedback captured via Padlet OR chat if time runs out.)

Closing

[5 minutes]

- Thank you so much for sharing your thoughts and experiences on NSF EPSCoR with us! The lessons learned from today will be incredibly valuable to NSF and the NSF EPSCoR visioning process.
- We encourage you to extend the discussion from today by visiting the Future of NSF EPSCoR website and responding to the public comment request.

APPENDIX F: LISTENING SESSION SUMMARY

Listening Session 1

The first listening session was conducted on September 24th, 2021, with 19 participants from Track-1 projects. The session covered three broad topics: innovation in research, program and jurisdictional effectiveness, and institutional diversity. Key themes include:

- Participants identified the following as innovations resulting from NSF EPSCoR: state-of-the-art instrumentation, patents, startups, centers, and institutes (although not STCs and ERCs), collaborations and partnerships, and the ability to support junior faculty/researchers.
- While some participants appreciated the five-year grant period and feel it is sufficient, others indicated that more time is needed.
- Participants identified post-grant and post-program sustainability as a challenge.
- Participants also noted the challenge of dispersing limited NSF EPSCoR funds state-wide, indicating it lessens the impact, and suggested NSF allow more than one Track-1 grant per jurisdiction.
- Participants often spoke of institutional diversity in terms of partnering with HBCUs, MSIs, TCUs, and PUIs to supply and support faculty, but also noted the importance of developing an inclusive culture and sense of belonging.
- Some jurisdictions may have more challenges recruiting and retaining qualified faculty due to small size, limited opportunities.
- Participants described measures of success as challenging: how to capture the full impact of NSF EPSCoR beyond eligibility, noting that standard metrics do not tell the full story.

Listening Session 2

The second listening session was conducted on October 15th, 2021, with 20 other NSF awardees such as CAREER. The session covered five broad topics: general feedback on NSF EPSCoR; outside-the-box solutions; statewide collaborative research; PUI, MSI, and TCU participation; and cross-jurisdictional collaboration. Key themes include:

- Participants identified the following as benefits of the program: the program's support for team building, funding for junior faculty early on in their careers to pursue research projects, and the flexibility of the program during the COVID-19 pandemic.
- While some participants appreciated the five-year grant period and feel it is sufficient, others indicated that more time is needed to build infrastructure and relationships.

- Participants identified the challenges of top-down relationships with larger research institutions, identifying other sources of funding for students to support the work, building strong collaborations with industry and lack of project management training.
- Participants identified the need to focus on what the PUIs do best and the comparative advantages of the NSF EPSCoR states rather than compete with well-developed research institutions on their terms.
- Participants felt there should be more cross-jurisdictional collaboration both within and across NSF EPSCoR states and NSF should support these opportunities through workshops.
- Participants identified post-grant and post-program sustainability as a challenge and suggested that the state and institution should support the projects in the future.
- Participants identified the possibility of post-baccalaureate, MA, and PhD students, as well as post-docs and undergraduates participating in institutional exchanges to promote relationships and share knowledge.

Listening Session 3

The third listening session was conducted on October 22nd, 2021, with 21 representatives of PUIs, MSIs, and TCUs. The session covered five broad topics: cross-jurisdictional collaboration, broadening participation, research and infrastructure capacity, education and workforce development, and outside-the-box solutions. Key themes include:

- Participants expressed that overall NSF EPSCoR supports cross-institutional collaborations. It has allowed them to share facilities, equipment, and other resources. The program also helps build the research capacity of smaller institutions.
- However, cross-collaboration is sometimes limited by the lack of research staff and leadership at MSI/TCU/PUIs.
- The current NSF EPSCoR funding formula prevents many MSIs from being able to receive EPSCoR funding. Thus, there is a greater need to emphasize collaboration across jurisdictions to help build participation and diversity.
- Participants suggested several ways that NSF EPSCoR funds could be used to help build research capacity, including course load reduction, administrative support, hands-on research by students, and REU-type experiences.
- Participants also suggested offering release time through NSF EPSCoR funding to allow time for effective outreach to underrepresented STEM students.
- Finally, participants suggested that NSF EPSCoR needs to be more culturally responsive by having greater representation of underrepresented groups during proposal reviews.

Listening Session 4

The fourth listening session was conducted on October 22nd, 2021, with 17 representatives from industry, state government, and community organizations. The session covered six broad topics: STEM research capacity and competitiveness, NSF investments, state/territory EPSCoR committees, partnerships, STEM capacity and economic development, and STEM capacity and K-12 education. Key themes include:

- Participants suggested that there is a need for a greater focus on K-12 education to grow the number of students pursuing careers in STEM.
- While some participants felt there was a need to focus on fundamental research, others felt that securing jobs for students should be a primary focus or that both research and industry support each other, and the strategy should be two-pronged.
- Participants gave several suggestions on strengthening collaboration between industry and academia.
- Participants suggested that NSF give more support and advice to the state committees.
- Participants felt that the funding cycle is too short to promote economic development which occurs over the course of a much longer time frame.

Listening Session 5

The fifth listening session was conducted on October 22nd, 2021, with 23 scholars in research competitiveness and capacity. The session covered three broad topics: early career faculty, research competitiveness, and jurisdiction and cross-jurisdictional support. Key themes include:

- Participants identified mentorship programs and support systems as critical in supporting early career faculty with their research competitiveness.
- Participants suggested greater opportunities to write teaching time release into grant applications.
- Participants suggested strategies for developing or sustaining research competitiveness include seed grants, gap funding, post-doc to faculty track programs, and greater flexibility in the topics funded by NSF EPSCoR.
- Participants suggested encouraging partnerships and collaboration rather than competition across NSF EPSCoR jurisdictions.
- Participants mentioned that jurisdiction-level leadership and politics matter for how NSF EPSCoR is utilized to build research competitiveness.
- Participants suggested encouraging events that bring together academic institutions, industry, and small businesses within an NSF EPSCoR jurisdiction to foster research activities that have an impact on the economy.

Listening Session 6

The sixth and last session was conducted on October 29th, 2021, with 23 university administrators. The session covered four broad topics: investments in research, promotion of entrepreneurship, long-term effectiveness and sustainability, and open-ended discussion. Key themes include:

- Participants noted the importance of federal support for research administration and leadership development because the lack of capacity in these areas in NSF EPSCoR jurisdictions/institutions limits their competitiveness.
- Participants supported shared core facilities and instrumentation, but with exceptions (i.e., where shared resources would not be feasible/conducive to research).
- Participants noted their disadvantage in terms of representation on Congressional and other national committees.
- Participants described facilitators of entrepreneurship and industry collaboration that included colocation, initial incentives for industry partnerships, entrepreneurial sabbaticals for faculty, and statewide structures.
- Participants provided several examples of Track-1 and Track-2 successes but indicated a need for substantially more investment in NSF EPSCoR (e.g., larger funding amounts, multiple Track-1 awards per jurisdiction).
- Participants described preconceived notions about NSF EPSCoR as an entitlement program and made an argument for emphasizing NSF EPSCoR jurisdictions' strengths and presenting these jurisdictions as a national resource to solve national problems.
- Some participants suggested that NSF and the Committee may want to think outside of the current track structure and brainstorm how to rebuild NSF EPSCoR from the ground up.

Listening Session Cross-Session Themes

- Participants across listening sessions indicated that NSF EPSCoR jurisdictions should receive more funding, in general. Specific recommendations include funding awards for longer periods than the current four or five years. Some participants noted that by the time projects have hit their stride, project managers need to shift toward end-of-grant activities and post-grant sustainability. Other participants explained that meaningful collaborations take considerable time to develop, and longer periods of support would allow collaborations to develop and deepen.
- Participants provided a wide range of suggestions regarding NSF's approach to funding NSF EPSCoR. Examples include adjusting eligibility to allow greater participation in the program

(for example, including institutions in non-NSF EPSCoR jurisdictions that would qualify if they were in an NSF EPSCoR jurisdiction), offering greater flexibility in how awardees can deploy program funds, and awarding more grants to new researchers rather than established investigators. Several participants also recommended that NSF allow more than one Track-1 award per jurisdiction.

- Participants recommended several additional tracks for the program. Specific recommendations varied but include tracks for PUIs, MSIs, including HBCUS, HSIs and TCUs; K-12; experimentation and innovation; postdocs; and small businesses similar to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs.

- Although participants across listening sessions highlighted the importance of developing their jurisdiction's physical research infrastructure, most of their specific infrastructure-related recommendations focused on developing their jurisdiction's human infrastructure. A common theme across listening sessions was the need for NSF funding in research management and administration, for example, covering facilities and administrative costs and providing management and leadership training. Participants described this as an area of weakness across many NSF EPSCoR institutions that significantly limits their ability to compete for funding.

- Specific recommendations were aimed at individuals in various stages of their education and career: K-12, undergraduate, and graduate students; K-12 teachers; post-baccalaureate and post-master's individuals; postdocs; and faculty, with an emphasis on faculty earlier in their career. The more common recommendations include funding release time for faculty so that they can engage more fully in research activities, investing in more research opportunities for students, providing opportunities for individuals to network and participate in career-building activities such as review panels, and establishing comprehensive and inclusive mentoring services or programs.

- Participants across listening sessions highlighted the importance of collaboration for capacity building and recommended a variety of ways in which NSF can support these efforts. Participants commonly advocated for more support of collaborations within and across jurisdictions and with industry, non-NSF EPSCoR jurisdictions, and other federal agencies, labs, programs. First, participants recommended greater collaboration within and across NSF EPSCoR jurisdictions. Specific examples include sharing equipment, facilities, and expertise; hosting lab exchanges; and convening workshops for awardees to learn from one another and potentially establish partnerships. It was suggested that NSF take a greater role in providing matchmaking services between jurisdictions, as well. Participants also discussed the need for closer alignment between academia and industry to induce industry involvement in NSF EPSCoR projects and spur economic development. With respect to non-NSF EPSCoR jurisdictions, participants recommended incentivizing these relationships, for example, by requiring non-NSF EPSCoR jurisdictions to include NSF EPSCoR partners in their projects. Finally, participants recommended that NSF increase its coordination with other

federal entities, for example, working more closely with the Economic Development Agency, the Directorate for Education and Human Resources, and the SBIR/STTR programs. Less commonly mentioned collaborations include those with K-12 systems and PUIs and TCUs, HBCU and other MSIs.

- Participants across listening sessions discussed ways to broaden the participation of PUIs and MSIs in NSF EPSCoR. Recommendations include creating a separate track focused on funding PUIs and MSIs, providing more funding to PUI and MSI partners, funding release time for faculty at these institutions for whom high teaching loads are often a barrier to research, and convening PUI- and MSI-driven workshops for participants to discuss common issues and potential partnerships. One participant, however, expressed concern about a separate track for MSIs. She explained that she values the fact that funds are set aside specifically for MSIs but encouraged NSF to ensure a level playing field for all individuals and institutions, for example, through a more equitable proposal review process.

- Participants across listening sessions indicated a need for NSF EPSCoR—at the national, jurisdiction, and project level—to better communicate the importance of the program, its contributions to the STEM enterprise, and its return on investment. Specific recommendations include funding program ambassadors who can spread the word about NSF EPSCoR and assist individuals and institutions interested in participating in the program, identifying better metrics to assess and convey the value of the program, and promoting the unique role NSF EPSCoR jurisdictions can play in addressing issues of national importance, for example, groundwater depletion and regeneration, mitigation of seasonal wildfires, and the effects of sea-level rise on populated islands. It was also suggested that NSF establish an NFS EPSCoR 10 Big Ideas initiative, similar to what is already in place for NSF as a whole. Table 4 below summarizes listening session participants' institutional affiliations.

TABLE 4. Classification of Listening Session Participants' Institutional Affiliations

Type	Count	Percentage
Doctoral Universities: Very High Research Activity	49	39.8%
Doctoral Universities: High Research Activity	13	10.6%
Doctoral/Professional Universities	2	1.6%
Master's Colleges & Universities: Larger Programs	4	3.3%
Master's Colleges & Universities: Medium Programs	11	8.9%
Master's Colleges & Universities: Smaller Programs	2	1.6%
Baccalaureate Colleges: Diverse Fields	1	0.8%
Baccalaureate/Associate's Colleges: Mixed	1	0.8%
Associate's Colleges: Mixed Transfer/Career & Technical-Mixed Traditional/Nontraditional	1	0.8%
Tribal Colleges and Universities	4	3.3%
NSF EPSCoR State Office	14	11.4%
Other*	21	17.1%
Total	**123**	**100.0%**

*Other includes non-academic institutions, such as private institutions.

APPENDIX G: ACCESSIBILITY CAPTIONS

Image 1., Pg. 13: [Image description: A feminine-presenting, Ph. D. student of color at Louisiana Tech University and Louisiana Materials Design Alliance (LAMDA) research, prepares a thermal camera for image capture during operation of a 3D printer.]

Image 2., Pg. 14: [Image description: A group of multi-racial students stand outside of the Haskell Environmental Research Studies Institute.]

Image 3., Pg. 16: [Image description: A feminine-presenting environmental engineer and professor of color, poses inside a lab holding lab equipment.]

Image 4., Pg. 24: [Image description: A masculine-presenting professor of color (center) instructs students from Colegio Rosa Bell during field work as part of a Basin Resilience to Extreme Events (BREE) summer program.]

Image 5., Pg. 27: [Image description: A masculine-presenting white student at the University of New Hampshire stands in front of a project that used a BioAssemblyBot acquired through NH BioMade.]

Image 6., Pg. 29: [Image description: A masculine-presenting, white professor points to a computer screen to indicate which single cells are being sorted to analyze their properties to see if the genes inhibit or contribute to viral infections.]

Image 7., Pg. 31: [Image description: Two women of color, a professor and her graduate student, work in a laboratory at Mississippi State University.]

Image 8., Pg. 33: [Image description: A group of multi-racial STEM students from the Wesley College Success in STEM (SIS) program stand in front of the Smithsonian Museum on a trip to Washington D.C.]

Image 9., Pg. 46: [Image description: A feminine-presenting, white graduate student adjusts an instrument at the John Olson Advanced Manufacturing Center at the University of New Hampshire.]

Image 10., Pg. 47: [Image description: A painting representing a diverse group of young students, including students of color and a student sitting in a wheelchair surround a sphere with colorful images representing the study of science such as planets, electricity, a double helix, a mountain range, and wheat.]

Image 11., Pg. 49: [Image description: A feminine-presenting and two masculine-presenting, white researchers work with biomass of sagebrush in a genome project in a laboratory at Boise State University.

APPENDIX H: REFERENCES

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