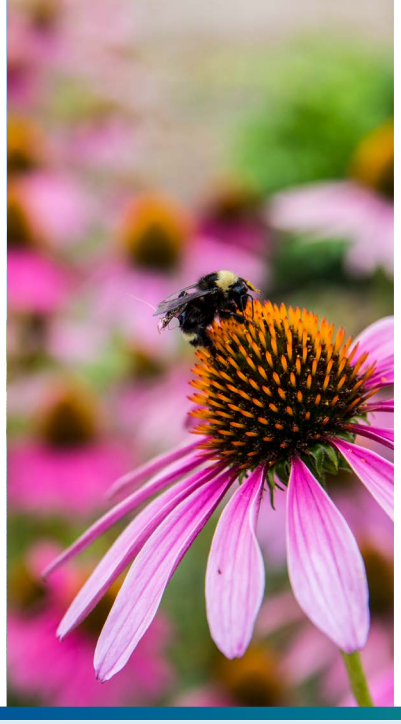
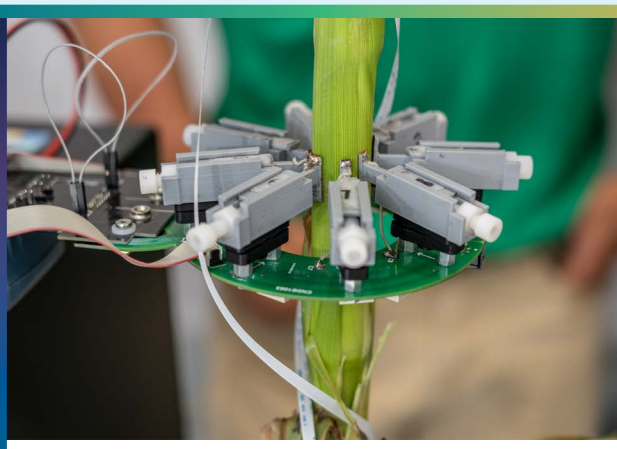
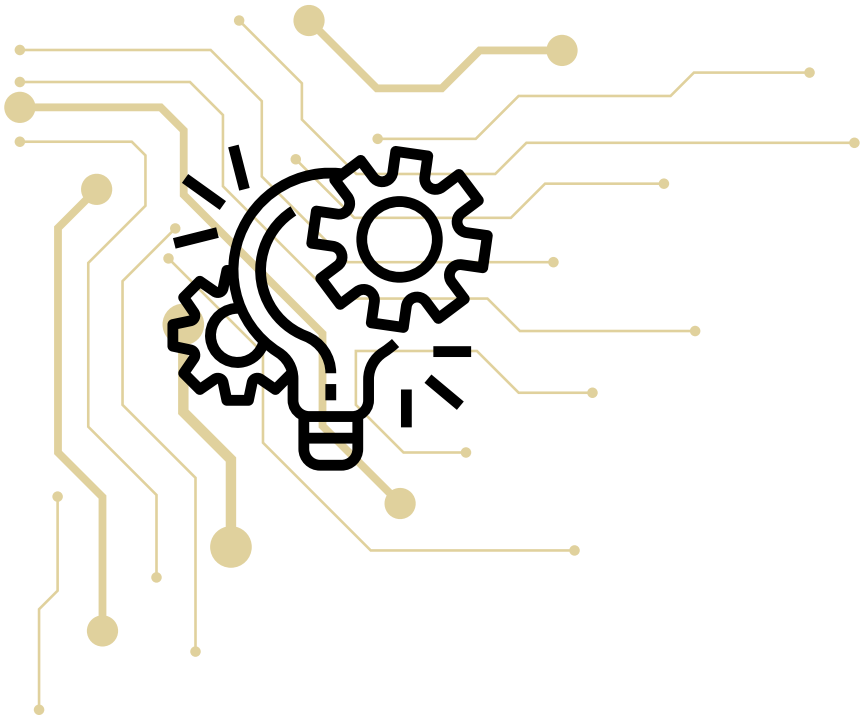




MAKING **VISIBLE** the INVISIBLE: STEM Talent of **Rural** America

2024 CEOSE Report to Congress





WRITING COMMITTEE MEMBERS

Tabbetha Dobbins, PhD (Writing Lead) | Suzanne Barbour, PhD | Jose Fuentes, PhD | Kaye Husbands Fealing, PhD |Cynthia Lindquist, PhD | James Martin, II, PhD

NSF LIAISONS

Dr. Bernice Anderson and Dr. Alicia J. Knoedler

CONSULTANTS

Trewon Technologies |Valentina Atela | Steven Buhneing |Gabriel Fabre | Gavin Flowers | Amanda Meyers

The Committee on Equal Opportunities in Science and Engineering (CEOSE) is charged by the United States Congress to advise the National Science Foundation (NSF) on polices, programs, and practices that encourage the full participation of women, underrepresented racial and ethnic populations, and persons with disabilities in science, technology, engineering, and mathematics (STEM).

Acknowledgements

The Committee on Equal Opportunities in Science and Engineering (CEOSE) is most appreciative of the time and expertise of the Writing Team for developing and preparing this special report for Congress. The Writing Team is commended for ensuring that the input from the CEOSE membership was incorporated in addressing the specified requirements of this report.

The Committee gives special thanks to the following senior officials and program directors at the National Science Foundation, who provided invaluable information and/or feedback to complete this report in a timely manner and to be helpful to the NSF and beyond:

Dr. James Moore, III
Assistant Director, Directorate for STEM Education (EDU)

Dr. Charles Barber,
NSF Chief Diversity and Inclusion Officer

Dr. Sylvia Butterfield,
Acting Assistant Director, Directorate for Social, Behavioral and Economic Sciences (SBE)

Dr. Jolene Jesse,
Former Acting Deputy Assistant Director, EDU

Dr. Monya Ruffin-Nash,
Acting Division Director, EDU

Dr. Bonnie Green,
Expert, EDU

Dr. Sandra Richardson,
Section Head, Research Capacity and Competitiveness/Office of Integrative Activities (OIA)

Dr. Laura Chase,
Lead Program Director, Tribal Colleges and Universities Program (TCUP), EDU

Dr. Tori Smith,
Lead Program Director, NSF Eddie Bernice Johnson INCLUDES Initiative, EDU

Dr. Toni Dancstep,
Program Director, Advancing Informal STEM Learning (AISL), EDU

Dr. Kathleen Bergin,
Former Lead Program Director, Robert Noyce Teacher Scholarship Program (NOYCE), EDU

Dr. Roland Roberts,
Deputy Chief Officer for Research Facilities, OD

Dr. Karen Cone,
Senior Advisor, BIO

Dr. Charlotte Roehm,
Program Director, National Ecological Observatory Network (NEON), BIO

Dr. Douglas Levey,
Program Director, Long-Term Ecological Research Program (LTER), BIO

This special report, MAKING VISIBLE the INVISIBLE: STEM Talent of Rural America, by the Committee on Equal Opportunities in Science and Engineering (CEOSE), fulfills a requirement of the recent CHIPS and Science Act of 2022. The requirements of the report include:(1) a description of past and present policies and activities of the Foundation to encourage full participation of students in rural communities in science, mathematics, engineering, and computer science fields; (2) an assessment of trends in participation of rural students in pre-kindergarten through grade 12 in the Foundation activities; and (3) an assessment of the policies and activities of the Foundation, along with proposals for new strategies or the broadening of existing successful strategies toward facilitating the goal of increasing participation of rural students in pre-kindergarten through grade 12 in Foundation activities.

CEOSE welcomes this opportunity to make more visible the diverse needs and opportunities of rural communities, particularly for pre-kindergarten through grade 12 students. However, NSF has a small portfolio of pre-kindergarten investments. Therefore, this report focuses mainly on K-12 STEM education. The key messages to be found in this report are: (1) a long history of NSF supporting rural STEM education through multiple initiatives, (2) the complexities of a changing society and advances in technologies that must be considered for future impacts, and (3) the need to ensure that NSF leverages the strengths and assets to grow past current initiatives and develop new ideas in support of rural STEM education in America. Ultimately, NSF can be a leader in improving the participation of K-12 students, making more visible the talent of rural communities for scientific breakthroughs and workforce diversity.

Relevant Past and Present Efforts

Over the years, NSF has embedded its support of opportunities for rural engagement in both its core values related to inclusivity and evolving policy documents encouraging the integration of research and education with broadening participation in STEM. The NSF Director expresses the significance of focusing on geographic diversity and talent development in the following statement in the agency's 2022-2026 strategic plan: "We need young inspiring scientists from every background to be part of a STEM community full of diverse perspectives that can drive the research enterprise to new breakthroughs and innovations and help solve our most pressing challenges" (National Science Foundation FY 2022 - 2026 Strategic Plan, p. 3).

NSF has had only one program focused solely on rural education[1]: the former **Rural Systemic Initiative (RSI)**, which was designed to improve the STEM K-12 education of five ethnically concentrated populations of K-12 students in rural America: African American, Alaska Native, American Indian, Poor Appalachian White, and Hispanic American. RSI funded approximately 30 projects that addressed the various challenges of the diversity of rural communities. Each RSI project developed a strategic plan to address community participation, parental involvement, resource convergence, leadership, partnerships, teacher development, and establishment of educational standards at the district level, while also considering local or regional differences and cultural circumstances. Additionally, the required strategic plan mandated outcome drivers, establishing targeted outcomes for levels of achievement over specific time frames. The RSI investment was a paradigm shift in how most rural school systems planned educational improvements in mathematics and science education (Harmon & Smith, 2012).

[1] The meaning of "rural" as an educational setting has been defined and conceptualized differently throughout rural education research. Rural schools differ in location, infrastructure, district size, student and minority enrollment, poverty rates, and socioeconomic standing (see Figure 1). This emphasizes that the unique educational needs of rural schools, which have historically been overlooked because of the generalization that all rural schools are grouped into a single descriptor, must be addressed (Brown, 2021).

Over several decades, NSF has consistently supported rural STEM education investments in four specific areas: informal science education, systemic reform/change initiatives, culturally responsive pedagogy, and teacher education. Current programs with projects advancing rural STEM education include **Advancing Informal STEM Learning (AISL)**, **the NSF Eddie Bernice Johnson INCLUDES Initiative**, **Discovery Research K-12 (DRK-12)**, **Innovative Technology Experiences for Students and Teachers (ITEST)**, **Computer Science for All (CSforAll)**, the **Robert Noyce Teacher Scholarship Program (NOYCE)**, and the **Tribal Colleges and University Program (TCUP) for Secondary and Elementary Teachers in STEM (TSETS)**. Various examples of projects in the current rural STEM education portfolio include the following:

- *Fostering Joint Parent/Child Engagement in Preschool Computational Thinking by Leveraging Digital Media, Mobile Technology, and Library Settings in Urban and Rural Communities* (NSF 2005975)*;*
- *STEM Pathways for Rural Youth: Developing STEM Identity through the Outdoors* (NSF 2213919)*;*
- *Cultivating Indigenous Research Communities for Leadership in Education and STEM (CIRCLES) Alliance* (NSF 2217344)*;*
- *Cultivating Exemplary STEM Teachers for High-Need Rural School Districts* (NSF 2151058)*;*
- *Developing STEM Teachers across Rural Schools: Using STEM Outreach Programs to Build and Strengthen Identity as STEM Teachers* (NSF 2243229)*;* and
- *Energizing STEM Teaching across Rural Schools* (NSF 2243433)*.*

Trends in Student Participation

Demographic statistics for rural students in NSF-supported activities over time were not readily available regarding students reached and served. Therefore, qualitative evidence, based on the NSF award database, was used to identify topical trends and recent influences on the delivery of innovative STEM opportunities for rural K-12 students over the past 20+ years. For example, different types of partnering relationships have emerged over time, such as the informal science professionals working with classroom teachers in rural schools to inspire and sustain student interest in STEM, collaborations between rural school districts and higher education institutions to innovate and reform learning activities to help improve the academic performance of rural students, and multi-sector partnerships designed to address student access and opportunities that give greater attention to the STEM workforce needs of rural communities. Additionally, NSF has been proactive in studying remote STEM education for rural K-12 students as well as leveraging technology to overcome the COVID-related disruptions in K-12 education. Another change observed over time is related to outreach activities shifting from a single motivational event to more meaningful engagement and collaboration, as seen in the educational initiatives of the **National Ecological Observatory Network (NEON)** and the **Long-Term Ecological Research (LTER)** programs.

The career development of STEM talent in rural schools and communities is becoming more innovative and mutually beneficial to the nation as rural school districts partner with institutions of higher education (IHEs) and career scientists across the STEM disciplines. Moreover, NSF has transitioned from a pipeline approach to STEM career development to framing multiple pathways to preparing for and pursuing a career in STEM fields. The emphasis on critical

transition to prevent leaks in the pipeline was revisited to focus on a more aspirational perspective of the various paths to pursuing STEM careers (sometimes called the "braided river" approach).

The expertise of formal and informal K-12 STEM rural communities with other STEM researchers and scholars are helping NSF to promote transformative strategies for integrating culturally inclusive, gender equity-driven, and adaptive design approaches for the meaningful and authentic participation of rural K-12 students in STEM activities. A brief review of active NSF awards supporting rural students indicated that students are participating in a wide range of cutting-edge opportunities for strengthening STEM education and early exposure to STEM careers. They include co-designed culturally sustaining STEM learning activities, use of libraries for virtual reality learning experiences, environmental STEM identity, multidisciplinary inquiry, project-based learning, leveraging of digital media and mobile technology to advance computational thinking, research-practice partnerships, and culturally responsive engineering education, to name a few.

Overall Assessment and Suggestions

NSF is committed to empowering rural communities to fully participate in scientific enterprises, including engagement with the K-12 students. Overall, the review of NSF's policies and activities revealed the following: the agency policies and practices are inclusive of rural communities, there is a long-standing history of varied K-12 activities for students and teachers in rural schools led by the NSF EDU Directorate, and there is a need for increased funding to address inequities and disparities among rural communities to continue and replicate successful practices as well as support innovative efforts that transform challenges into promising and innovative opportunities to help rural K-12 students excel in STEM education.

Some of the successful strategies for K-12 STEM education in rural schools to scale (with speed) for increased student participation include the following:

- Ensuring that students at every level of education have access to experiential activities that will strengthen/enhance academic preparation for the STEM career trajectory;
- Providing financial support, especially scholarships, to increase access to a STEM degree and reduce/eliminate the financial burden of earning a STEM degree;
- Leveraging technology to address resource and performance disparities by helping students succeed in STEM courses/coursework and persist in the STEM pathways;
- Bridging formal and informal STEM education experiences to fill in the gaps around exposure, interests, and preparation (including using family, intergenerational, and community-based STEM events and training);
- Leveraging existing investments in place-based research (e.g., NEON and LTER) to engage "diverse community voices," including rural K-12 students in authentic and meaningful STEM research; and
- Strengthening mentorship opportunities; and supporting knowledge mobilization to compile and share exemplary practices and strategies to improve STEM teaching and learning in the rural context.

Additional suggestions for increased participation of K-12 rural students in NSF activities are highlighted in Table 2 of the report. CEOSE will continue to advise NSF on opportunities to support and sustain high-quality teaching, place-based learning, community-driven research, and dual enrollment opportunities in rural schools, recognizing the value of rural education for contributions to workforce diversity, national security, leadership in science and engineering, and economic growth through innovation.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

AI	Artificial intelligence
AISL	Advancing Informal STEM Learning
ALL-SPICE	The NSF INCLUDES Alliance Supporting Pacific Impact through Computational Excellence
ANS	Arctic Natural Sciences
ASSP	Arctic Social Sciences Program
ATE	Advanced Technology Education
BCS	Division of Behavioral and Cognitive Sciences
BCSER	Building Capacity in STEM Education Research
BIO	Directorate for Biological Sciences
CEOSE	Committee on Equal Opportunities in Science and Engineering
CIRCLES	Cultivating Indigenous Research Communities for Leadership in Education and STEM Alliance
CISE	Directorate for Computer and Information Science and Engineering
CLT	Centers for Teaching and Learning
CoPe	Coastlines and People Program
CSforAll	Computer Science for All
EDA	Economic Development Administration
EDU	Directorate for STEM Education
ENG	Directorate for Engineering
EngEd	Engineering Education
EPSCoR	Established Program to Stimulate Competitive Research
EnvS	Environmental Science
DGE	Division of Graduate Education
DRK-12	Discovery Research K-12
DRL	Division of Research in Formal and Informal Settings
DUE	Division of Undergraduate Education
ECR	EDU Core Research
EWF	Education and Workforce Program
EWFD	Engineering Workforce Development
FEC	Focused EPSCoR Collaboration
FW-HTF	Future of Work at the Human-Technology Frontier
GEO	Directorate for Geosciences
GK-12	Graduate STEM Fellows in K-12
GOLD	Geoscience Opportunities for Leadership in Diversity
HCC	Human Centered Computing
HSI	Hispanic-Serving Institutions
I-Corps	NSF's Innovation Corps
IHEs	Institutions of Higher Education
IIS	Information and Intelligent Systems
IMD	Instructional Materials Development

INCLUDES	Eddie Bernice Johnson Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science Initiative
ISE	Informal Science Education
ITEST	Innovative Technology Experiences for Students and Teachers
IUSE	Improving Undergraduate STEM Education
LIFEways	Learning in and from the Environment through Multiple Ways of Knowing
LTER	Long-Term Ecological Research
MiRSI	Michigan Rural Systemic Initiative
MPS	Directorate for Mathematical & Physical Sciences
MPS-High	MPS High School Research Assistantships
MSI	Minority-Serving Institutions
MSP	Math and Science Partnership
MTF	Master Teaching Fellowships
NAEP	National Assessment Education Progress
NASEM	National Academies of Science, Engineering, and Medicine
NEON	National Ecological Observatory Network
NOYCE	Robert Noyce Teacher Scholarship Program
NSF	National Science Foundation
PAARE	Partnerships in Astronomy & Astrophysics Research and Education
POSE	Pathways to Enable Open-Source Ecosystems
PUSH	STEM Pathways for Underrepresented Students to Higher Education Network
RAPID	Rapid Response Research grants
RAHSS	Research Assistantship for High School Teachers and Students
RISC	Rural Informal STEM Conference
RESS	Research Experiences in STEM Settings
RET	Research Experiences for Teachers
REU	Research Experiences for Undergraduates
RSI	Rural Systemic Initiative
S-STEM	Scholarships in Science, Technology, Engineering, and Mathematics Program
S&S	Scholarships and Stipends
SBE	Directorate for Social, Behavioral and Economic Sciences
SBE-High	High School Research Assistantships in the Social, Behavioral and Economic Sciences
SfS	CyberCorps Scholarship for Service
SKC	Salish Kootenai College
STEM	Science, Technology, Engineering, and Mathematics
TE	Teacher Enhancement
TPC	Teacher Professional Continuum
TIP	Directorate for Technology, Innovation and Partnerships
TCUP	Tribal Colleges and University Program
TSETS	Teaching Fellowships Tribal Colleges and Universities Program for Secondary and Elementary Teachers in STEM

1.1 CEOSE Requirement in the CHIPS and Science Act of 2022

In the recent CHIPS and Science Act, the Committee on Equal Opportunities in Science and Engineering (CEOSE) is required to submit to Congress a report that includes the following:

1. a description of past and present policies and activities of the Foundation to encourage full participation of students in rural communities in science, mathematics, engineering, and computer science fields;
2. an assessment of trends in participation of rural students in pre-kindergarten through grade 12 in Foundation activities; and
3. an assessment of the policies and activities of the Foundation, along with proposals for new strategies or the broadening of existing successful strategies towards facilitating the goal of increasing participation of rural students in pre-kindergarten through grade 12 in Foundation activities.

This requirement closely aligns with CEOSE's current thematic focus of "Making Visible the Invisible." Specifically, in previous biennial reports, CEOSE emphasized the need to support diverse community voices and recognize severely underrepresented groups for new perspectives to broaden participation in STEM and advance scientific innovation. CEOSE welcomes this opportunity to make more visible the diverse needs and opportunities of rural communities, as well as leverage their strengths and assets.

This special report responds to the Congressional requirement for CEOSE to report on the participation of rural students in STEM, particularly K-12 students reached and/or directly supported by NSF activities. Additionally, innovative approaches and successful strategies for advancing STEM knowledge and participation of rural K-12 students are included. The current pre-kindergarten STEM portfolio highlights early childhood support for promoting STEM learning via family engagement, exploratory informal learning experiences, new technologies, and direct attention to the rural community culture. Find the list of projects in Appendix A of this report.

Figure 1: *Defining "Rural" Education*

DEFINING "RURAL" EDUCATION

In general, five qualitative characteristics are associated with rural education:

- Education takes place at a distance from large urban areas.
- Education has access to fewer resources, such as high-quality professional development and curricula.
- Education takes place in small schools.
- Education cooperates with and tries to meet the needs of the community and local economy.
- Education is placed or rooted in the lives of community families (Kettler et al., (2015), p. 247 - 248).

Note: Adapted from Brown, 2021.

1.2 Rural Context

All states in America have rural communities. However, rural America is often overlooked for its untapped pool of STEM talent. As NSF advances its goal of creating opportunities everywhere, it is important to acknowledge the assets of rurality in broadening the participation of the STEM enterprise. For example, consider the following fast facts[2] on the status of rural education taken from the *Condition of Education* 2023 report, the National Assessment of Educational Progress (NAEP) mathematics, science, and reading assessments, and a *Why Rural Matters 2023* report that needs to be leveraged as we move forward in preparing the next generation of STEM innovators, researchers, and educators.

The *Condition of Education* 2023 report indicated:

- In 2019–2020, about 90,000 schools (92 percent) were traditional public schools and served 50.8 million students.
- Approximately 29 percent of traditional public schools were located in rural areas, enrolling 9.8 million students.
- In the fall of 2019, the demographics for students in rural areas were: White (68 percent), Hispanic (15 percent), Black (9 percent), American Indian or Alaska Native (4 percent), and Asian (4 percent) (Figure 2).
- Additionally, 14 percent of children ages 5–17 living in rural areas were below the poverty line in 2019.
- In 2019, the adjusted cohort graduation rate for rural areas was 90 percent compared to 89 percent for suburban areas.

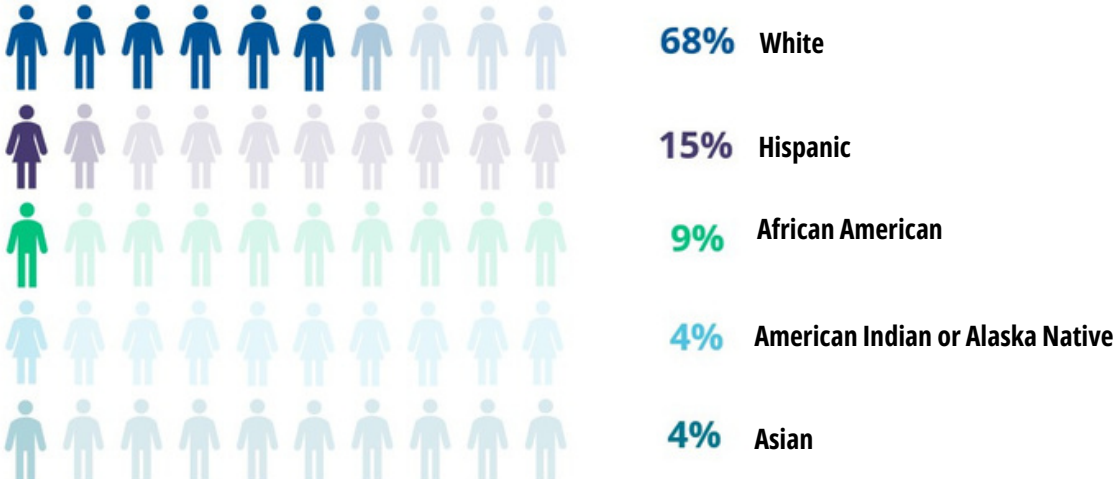
The National Assessment of Educational Progress (NAEP) mathematics, science, and reading assessments 2019 report card revealed:

- Nationwide, 37 percent of 4th-grade public school students in rural areas scored at or above the "Proficient" level on the 2019 NAEP science assessment. This was higher than the national average (36 percent).
- Nationwide, 34 percent of 8th-grade public school students in rural areas scored at or above the "Proficient" level on the 2019 NAEP science assessment, 1 percent lower than the national average (35 percent) (Figure 3).
- Nationwide, 18 percent of 12th-grade public school students in rural areas scored at or above the "Proficient" level on the 2019 NAEP science assessment, 2 percent lower than the national average (20 percent).
- Nationwide, 33 percent of 4th-grade public school students in rural areas scored at or above the "Proficient" level on the 2019 NAEP mathematics assessment, higher than the national average (32 percent).
- Nationwide, 25 percent of 8th-grade public school students in rural areas scored at or above the "Proficient" level on the 2019 NAEP mathematics assessment, 1 percent higher than the national average (24 percent) (Figure 3).
- Nationwide, 18 percent of 12th-grade public school students in rural areas scored at or above the "Proficient" level on the 2019 NAEP mathematics assessment, 3 percent lower than the national average (21 percent).

[2] The fast facts presented in this report largely depict rural education as defined by general locale.

Figure 2

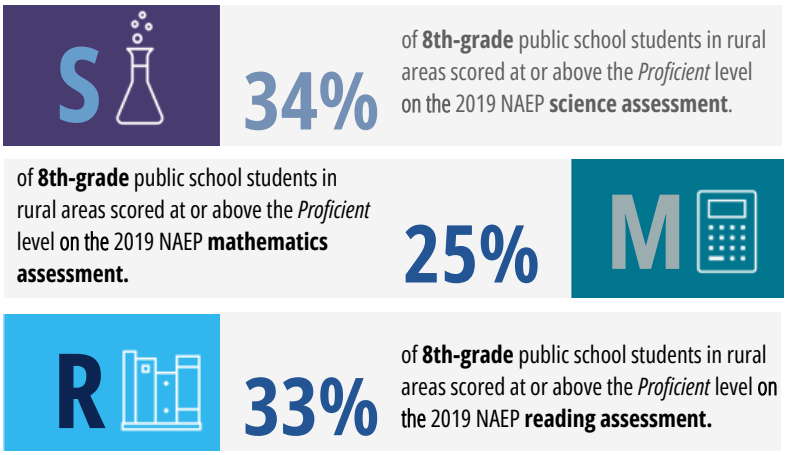
Percentage Distribution of Public Elementary and Secondary School Student Enrollment in Rural Areas By Race/Ethnicity in Fall 2019



Note. In fall 2019, the percentage of White students was higher (68 percent) in rural areas compared to Hispanic (15 percent), Black (9 percent), American Indian or Alaska Native (4 percent), and Asian (4 percent).

Figure 3

2019 National Assessment Education Progress (NAEP) 8th Grade Mathematics, Science, and Reading Achievement-Level Results



Note: Nationwide, 34 percent of 8th-grade public school students in rural areas scored at or above the "Proficient" level on the 2019 NAEP science assessment, 1 percent lower than the national average (35 percent). Nationwide, 25 percent of 8th-grade public school students in rural areas scored at or above the "Proficient" level on the 2019 NAEP mathematics assessment, higher than the national average (24 percent). Nationwide, 33 percent of 8th-grade public school students in rural areas scored at or above the "Proficient" level on the 2019 NAEP reading assessment, 1 percent lower than the national average (34 percent).

- Nationwide, 34 percent of 4th-grade public school students in rural areas scored at or above the "Proficient" level on the 2019 NAEP reading assessment, 1 percent lower than the national average (35 percent).

- Nationwide, 33 percent of 8th-grade public school students in rural areas scored at or above the "Proficient" level on the 2019 NAEP reading assessment, 1 percent lower than the national average (34 percent) (Figure 3).

- Nationwide, 35 percent of 12th-grade public school students in rural areas scored at or above the "Proficient" level on the 2019 NAEP reading assessment, 2 percent lower than the national average (37 percent).

Why Rural Matters 2023 report:

- At least half of public schools are rural in 13 states: Montana, South Dakota, Vermont, North Dakota, Maine, Alaska, Oklahoma, Nebraska, Wyoming, New Hampshire, Iowa, Mississippi, and West Virginia. Other Established Program to Stimulate Competitive Research (EPSCoR) states and territories also have a significant number of rural public schools, which suggests that EPSCoR jurisdictions have a major responsibility for reaching rural communities (Figure 4).

With increased national focus on encouraging the full participation of students in rural communities in STEM fields, challenging contextual factors cannot be overlooked either. For example, the 2019 national data in the *Conditions of Education 2023* report stated that 14 percent of children aged 5-17 in rural areas were living in poverty. Living in poverty has been associated with lower-than-average academic performance. Twenty-six (26) percent of students in kindergarten through grade 12 had parents or guardians who had earned a bachelor's degree or completed some graduate coursework as their highest level of education. Researchers have found that living in a household without a parent who has completed high school is associated with poor educational and attainment outcomes.[3]

In "Nurturing STEM Talent in Rural Settings," Lakin et al. (2021) describe how rural students face several challenges that can keep them from pursuing college degrees and careers in STEM fields. Compared to their urban and suburban counterparts, rural students are less likely to have family members or neighbors who work in STEM fields, limiting their access to STEM role models. Rural schools tend to receive less outreach from industry representatives who can provide students in rural areas with early exposure to STEM careers. Also, many rural schools are quite small, making it harder for rural students with STEM-related interests to find like-minded peers. Many rural districts are unable to offer the advanced math and science courses that college STEM programs may require as prerequisites. Research results show that rural children are less likely to attend college, and those who do attend are 60 percent less likely to enroll in STEM majors and less likely to persist in STEM fields of study than their urban and suburban peers.

[3] *The Conditions of Education 2023*. For more information, see https://nces.ed.gov/pubs2023/2023144rev.pdf

Additionally, a concern that should be explored is whether today's rural students may worry that pursuing a STEM career will require them to leave their hometowns to obtain the necessary credentials (e.g., bachelor's degrees) and find meaningful work because many STEM jobs are found closer to a city hub.

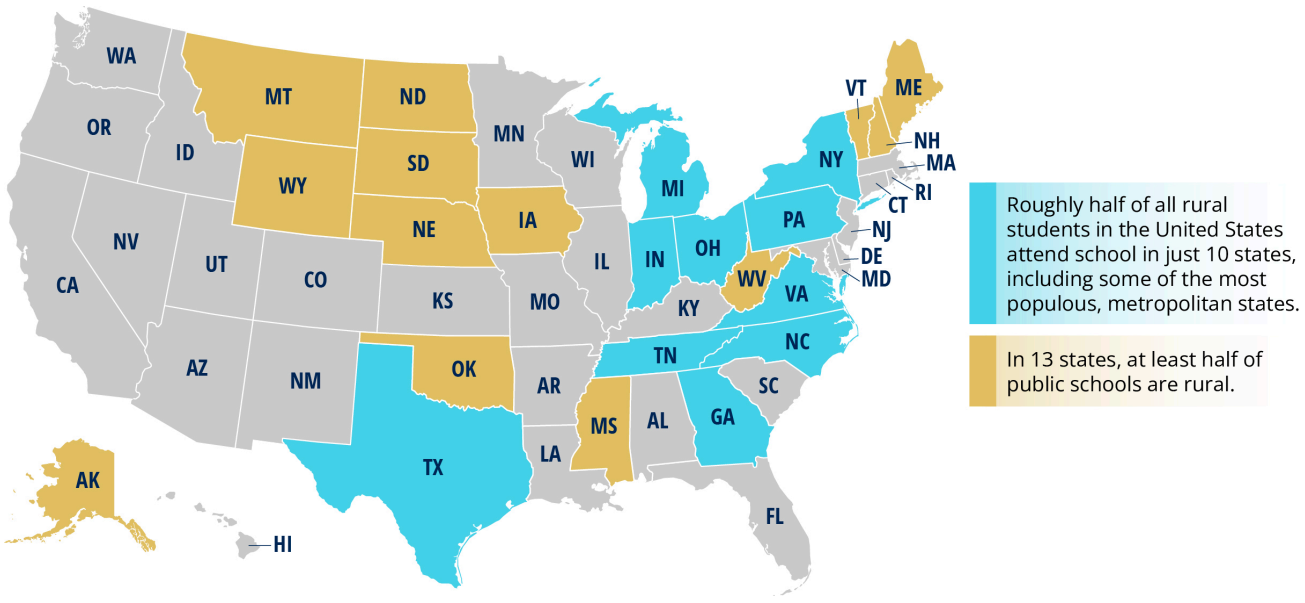
Alternatively, many involved in workforce development in rural communities are concerned about the potential for a "brain drain," meaning the loss of rural-raised community members who depart for college and do not return.

For universities located in rural settings, the impending demographic shift could be amplified (over and above the effects experienced by colleges/universities near urban centers) if the young populations in rural communities do not pursue college degrees from local institutions.

These complex situations represent unique opportunities for NSF to be a leader in the geography of innovation and production of STEM talent by making visible the talent in rural communities for scientific breakthroughs as well as workforce diversity. The remainder of this report will be focused specifically on understanding and improving the participation of K-12 rural students in NSF STEM activities, highlighting diversity within rurality through programs and project-level examples. Efforts will differ within, between, and among rural communities, given geographic and cultural factors.

Figure 4

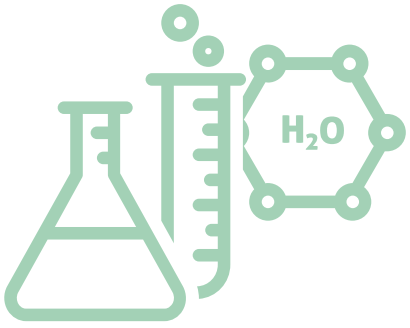
States with the highest public-school distribution in rural areas



Note: At least half of public schools are rural in 13 states: Montana, South Dakota, Vermont, North Dakota, Maine, Alaska, Oklahoma, Nebraska, Wyoming, New Hampshire, Iowa, Mississippi, and West Virginia. Adapted from "Why Rural Matters 2023," by Showalter, D., Hartman, S.L., Eppley, K., Johnson, J., & Klein, R., 2023, Centering equity and opportunity. National Rural Education Association, p. 3. Copyright 2023 by National Rural Education Association.

As described in the National Science Foundation 2022-2026 Strategic Plan, the NSF vision is "a nation that leads the world in science and engineering research and innovation, to the benefit of all, without barriers to participation."[4] NSF leadership has emphasized "accessibility and inclusivity" in the scientific enterprise to create opportunities everywhere. This visionary pillar for broadening participation in STEM is linked to an agency's core value of diversity and inclusion and the first strategic goal, "empower STEM talent to fully participate in science and engineering,"[5] and is further emphasized in NSF's grants policy document. The NSF Director expresses the significance of focusing on geographic diversity and talent development in the following statement in the agency plan, "We need young inspiring scientists from every background to be part of a STEM community full of diverse perspectives that can drive the research enterprise to new breakthroughs and innovations and help solve our most pressing challenges."

Geographic diversity in terms of high-quality STEM education for rural communities has been supported by NSF since its early to current investments in four specific areas: (1) informal science education, (2) systemic reform/change initiatives, (3) culturally responsive pedagogy, and (4) teacher education and K-12 STEM career development (Figure 5).



2.1 Informal Science Education

NSF has funded noteworthy projects to provide mathematics and science education research and resources to support young learners and families in rural settings, as well as to augment professional development training and resources to help rural K-12 teachers increase their students' access to hands-on learning opportunities within and in out-of-school settings. Since the 1980s, the **Informal Science Education (ISE)** investment has emphasized a lifelong learning ecosystem and learning science in informal environments any time, any place, and anyone (Ucko, 2010).

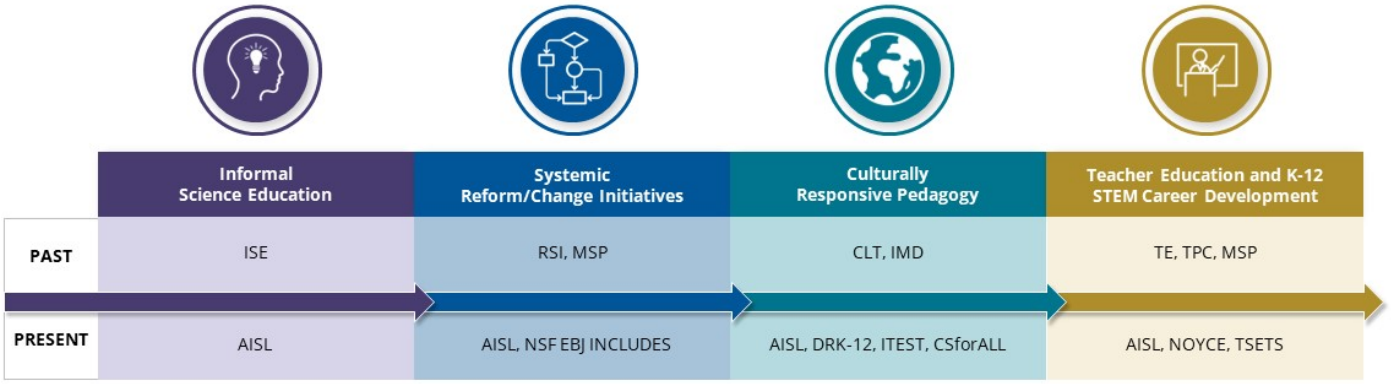
The current program, **Advancing Informal STEM Learning (AISL)**, continues supporting various rural community projects to strengthen STEM skills, promote scientific literacy, and inspire the next generation of the science and engineering (S&E) and skilled technical workforce (STW), including through informal STEM learning and ways of knowing within historically excluded and underserved communities. With 25 percent of AISL's projects focused on rural communities over the past decade, AISL projects contribute to the research and practice that "further illuminates informal STEM learning's role in equity and belonging in STEM; personal and educational success in STEM; advancing public engagement in scientific discovery; fostering interest in STEM careers; creating and enhancing the theoretical and empirical foundations for effective informal STEM learning; improving community vibrancy; and/or enhancing science communication and the public's engagement in and understanding of STEM and STEM processes."[6]

[4] National Science Foundation (2022). *Leading the world in discovery and innovation, STEM talent development and the delivery of benefits from research-NSF strategic plan for Fiscal Years (FY) 2022-2026*.
[5] National Science Foundation (2022). *Leading the world*.

[6] National Science Foundation. Advancing Informal STEM Learning (NSF AISL). Program Solicitation NSF 22-626. https://new.nsf.gov/funding/opportunities/advancing-informal-stem-learning-aisl

Figure 5

NSF Past and Present Support for Rural K-12 STEM Education



Note. NSF efforts in expanding STEM interest and awareness started well in the 1980's with informal science education. By the early 90's, efforts expanded to Systemic Reform/Change Initiatives. Prior to 2002, efforts also largely focused on teacher enhancement, and NOYCE was established. By 2006, NSF efforts shifted from age-appropriate resources to standards-based materials in terms of instructional materials development, then Culturally Responsive Pedagogy. Programs supporting these efforts included DRK-12. In present day, NSF efforts in increasing STEM interest, awareness, and learning are geared toward STEM career development in the K-12 education sector to influence the preparation and participation of the future STEM workforce. It is also important to note that there are changes in priorities that come with different administrative priorities.

There are five types of AISL projects: (1) Synthesis; (2) Conference; (3) Partnership Development and Planning; (4) Integrating Research and Practice; and (5) Research in Support of Wide-Reaching Public Engagement with STEM. Examples of rural STEM education projects include: *Enhancing Learning Opportunities in Libraries of Rural Communities* (NSF 1906172); *Fostering Joint Parent/Child Engagement in Preschool Computational Thinking by Leveraging Digital Media, Mobile Technology, and Library Settings in Urban and Rural Communities* (NSF 2005975); and *STEM Pathways for Rural Youth: Developing STEM Identity through the Outdoors* (NSF 2213919).

Particularly noteworthy examples of projects focusing on Indigenous education include: *Informal Biodiversity Education Models for Rural and Tribal Youth* (NSF 2313972), *Kaulele (to Take Flight)—Creating a Native Hawaiian Pacific Islander Indigenous--Led Design Framework for STEM Exhibits* (NSF 2314144), and *Developing a Place-Based STEM Education Model for Cultural Connections to Alaska Science* (NSF 2201324). Figure 6 highlights the work of researcher Nancy Maryboy, who is also involved in *Water in the Four Corners Region: Libraries and Exhibits Connecting and Engaging Communities with Their Water Systems* (NSF 1907024) and *Learning in and from the Environment through Multiple Ways of Knowing (LIFEways)* (NSF 2218903).

Figure 6

Presentation to CEOSE in Support of Native Communities Advancing Informal STEM Learning

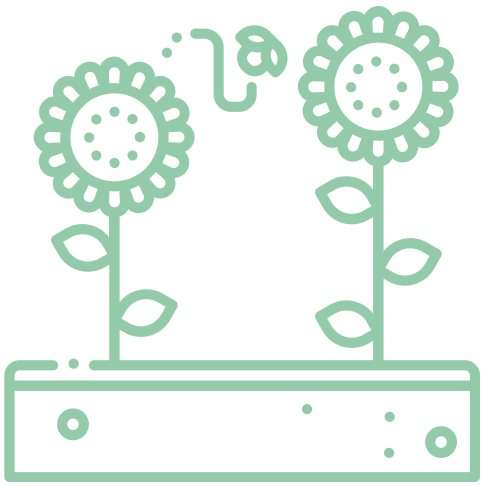
Note. Adapted from "Bringing an awareness to native voice of ways of knowing", by N. Maryboy, 2022. CEOSE Advisory Committee Virtual Meeting Panel: Centering the Voices of those Often Excluded: K-12 and Informal STEM Education Research Perspectives.

The STEM informal science learning community is advancing a sense of localism and value of place as an asset of rural STEM education by increasing student/family/community participation in outdoor, hands-on intergenerational learning experiences. The "rural cultural relevant" context is important for both formal and informal science education. STEM connections to local phenomena or solving problems in local settings can help promote a sense of belongingness in the scientific enterprise.

2.2 Systemic Reform/Change Initiatives

The former NSF Division of Educational System Reform established the **Rural Systemic Initiative (RSI)** in 1994, designed to provide high-quality mathematics and science education in rural America. NSF invested more than $140 million in RSI to improve the STEM K-12 education of five ethnically concentrated populations of K-12 students in rural America: African American, Alaska Native, American Indian, Appalachian White poor, and Hispanic American.[7] RSI funded approximately 30 projects that addressed the various challenges of the diversity of rural communities.

The NSF's theoretical framework required that each RSI develop a strategic plan to address community participation, parental involvement, resource convergence, leadership, partnerships, teacher development, and establishment of educational standards at the district level, while also considering local or regional differences and cultural circumstances. In addition, the required strategic plans mandated outcome drivers, establishing targeted outcomes for levels of achievement over specific time frames. This was a paradigm shift in how most rural school systems planned educational improvements in mathematics and science education.[8]



The latest large-scale STEM investment at the Foundation is the current **NSF Eddie Bernice Johnson Inclusion across the Nation of Communities of Learners of Underrepresented Discoverer in Engineering and Science (INCLUDES)** Initiative that must "operationalize five design elements of collaborative infrastructure (1) shared vision, (2) partnerships, (3) goals and metrics, (4) leadership and communication, and (5) expansion, sustainability, and scale. The INCLUDES initiative aims to create systemic change that will lead to the substantially broadened participation of individuals from historically excluded and under-served groups in STEM."[9]

This initiative began in 2016 as one of NSF's 10 Big Ideas of long-term research and process ideas for future investments at the frontiers of science and engineering and in response to the CEOSE 2011-2012 recommendation that the NSF needed to implement a bold new initiative to broaden participation of persons from populations underrepresented in STEM. Several projects are serving rural students/ communities. The *STEM Pathways for Underrepresented Students to Higher Education (PUSH) Network*, for instance, is leveraging the power of K-12 STEM programs to broaden the participation of Black, Indigenous, and/or Latinx students in STEM (NSF 1930990). Another example is the *Alliance Supporting Pacific Impact through Computational Excellence (ALL-SPICE)*, (NSF 2217242), harnessing the data revolution to support sustainability, economic development, and social justice in the Hawaii Pacific region. Also, the *First2 Network Alliance* is improving STEM persistence among first-generation, rural, and other underrepresented students so they, in turn, can contribute to the innovation economy in West Virginia (NSF 1834569).

[7] H. Harmon and K. Smith (2012). Legacy of the Rural Systemic Initiatives: Innovation, leadership, teacher development, and lessons learned. Nashville, TN: Edvantia, Inc.

[8] H. Harmon and K. Smith (2012). Legacy of Rural.

[9] National Science Foundation. Inclusion across the Nation of Communities of Learners of Underrepresented Discovers in Engineering and Science (NSF INCLUDES). Program Solicitation NSF 22-622.

Six EPSCoR States - Idaho, Montana, New Mexico, North Dakota, South Dakota, and Wyoming - established the *Cultivating Indigenous Research Communities for Leadership in Education and STEM (CIRCLES) Alliance* to develop Native-based activities for K-12 and higher education students in order to address the severe underrepresentation of American Indians in STEM (NSF 2217344). Encouraging system-wide change to reach the critical masses can be successful in rural STEM education.

Culturally Responsive Pedagogy

The development of age-appropriate, standard-based instructional practices and resources, supported by former programs like the **Centers for Teaching and Learning (CLT)** and the **Instructional Materials Development (IMD)**, has shifted over time to increased emphasis on culturally responsive pedagogy.

Currently, across the NSF Directorate for STEM Education (EDU) award portfolio, there is support for research to understand and address the barriers to high-quality STEM education in various geographic areas and research on exploratory efforts to improve the quality of STEM learning in rural communities. The Division of Research on Learning in Formal and Informal Settings (DRL) aims to advance early, promising innovations and larger-scale adoptions of proven educational innovations, including increasing broadband connectivity and place-based learning. In doing so, it challenges the field to create the ideas, resources, and human capacity to transform STEM education for the 21st century.

In addition to AISL, the following three programs in DRL offer opportunities for advancing research, development, and field-based improvement/culturally relevant strategies for STEM education of K–12 students including students in rural areas. In a rural context, this might mean STEM learning activities and examples are connected to the historical roots of an agrarian culture, are place-based, are integrated with daily community life, and are connected to local organizations such as 4-H.

- The **Discovery Research K-12 (DR- K12)** program enables significant advances in K-12 student and teacher learning of the STEM disciplines, through research and development of innovative resources, models, and technologies for use by students, teachers, administrators, and policy makers.

- The **Innovative Technology Experiences for Students and Teachers (ITEST)** program engages students and teachers in creatively using information technologies within the context of STEM learning experiences in school and other learning settings.

- The **Computer Science for All (CSforAll)** program provides all U.S. students with opportunities to participate in high-quality computer science and computational thinking education at the preK-12 levels. To this end, it supports fundamental research on learning and instruction of computer science and computational thinking and supports research-practice partnerships to increase instructional capacity in schools.

Collectively, these DRL programs and other related STEM education funding opportunities are supporting a key action suggested by the report on the future of the STEM education visioning process; that is, provide "culturally relevant and context-appropriate learning experiences coupled with the modern technologies [that] are particularly adapted to and important in rural, underserved, or under-resourced communities where access to STEM resources and experiences can be more limited."[10]

[10] STEM Education for the Future: A Visioning Report. 2020 https://www.nsf.gov/edu/Materials/STEM%20Education%20for%20the%20Future%20-%202020%20Visioning%20Report.pdf

Additionally, the **EDU Core Research** program is an EDU-wide funding opportunity that supports fundamental research that might include teachers and rural students, especially studies focused on upscaling and reskilling K-12 teachers. This program provides an opportunity to help address assumptions/ misconceptions by employing or utilizing intersectional research to study commonalities and differences that can be leveraged for advancing rural STEM talent.

2.4 Teacher Education

NSF addressed the number and quality of teachers for K-12 STEM education through several significant past and current investments. One past example before and concurrently with systemic reform efforts was the **Teacher Enhancement (TE)** program that supported the development of research-based, replicable/adaptable models for career-long development of the instructional workforce. Later, the **Teacher Professional Continuum (TPC)** funding opportunity addressed the full continuum of K-12 teacher education from recruitment and preparation, through enhancement, retention, and life-long learning of science, mathematics, and technology teachers. The **Math and Science Partnership (MSP)** program established in 2002, was a major research and development effort that supported innovative partnerships to improve K-12 student achievement in mathematics and science, largely led by higher education institutions. The MSP program was part of Former President Bush's No Child Left Behind initiative to strengthen and reform education by supporting partnerships that enhanced the capacity of schools to provide challenging curricula, encouraged more students to succeed in advanced mathematics and science, and increased the number, quality, and diversity of mathematics and science teachers, especially in underserved areas.[11]

Additionally, the **Graduate STEM Fellows in K–12 (GK-12) Education** program, funded from 1999–2011, supported fellowships and training for STEM graduate students who spent one to two years in partnership with K–12 teachers while continuing their academic work. "Through interactions with teachers and students in schools, the 'graduate fellows' improved their communication and teaching skills while enriching STEM content and instruction for their K–12 partners."[12]

While the **Robert Noyce Teacher Scholarship** program seeks to support schools and teachers in high-need school districts across the nation, it also reflects NSF's primary work in improving access to well-qualified teachers skilled to teach STEM classes in rural, high-need school systems. Authorized in 2002, the **Noyce** program provides scholarships, stipends, and programmatic support to STEM majors and professionals to become K–12 teachers in high-need school districts.

The current **Noyce** program offers four program tracks: 1: The Robert Noyce Teacher Scholarships and Stipends (S&S) Track, 2: The NSF Teaching Fellowships (TF) Track, 3: The NSF Master Teaching Fellowships (MTF) Track, and 4: The Noyce Research Track. In addition, Capacity Building proposals are accepted from proposers intending to develop a project in any of the program's tracks. **Noyce** also supports conference proposals focused on improving STEM teacher preparation. Proposals that support authentic Research Experiences in STEM Settings (RESS) for Noyce and/or non-Noyce pre-service and in-service STEM teachers are also invited.[13]

[11] NSF Fact Sheet: Math and Science Partnership. February 4, 2002. https://www.nsf.gov/news/news_summ.jsp?cntn_id=102976

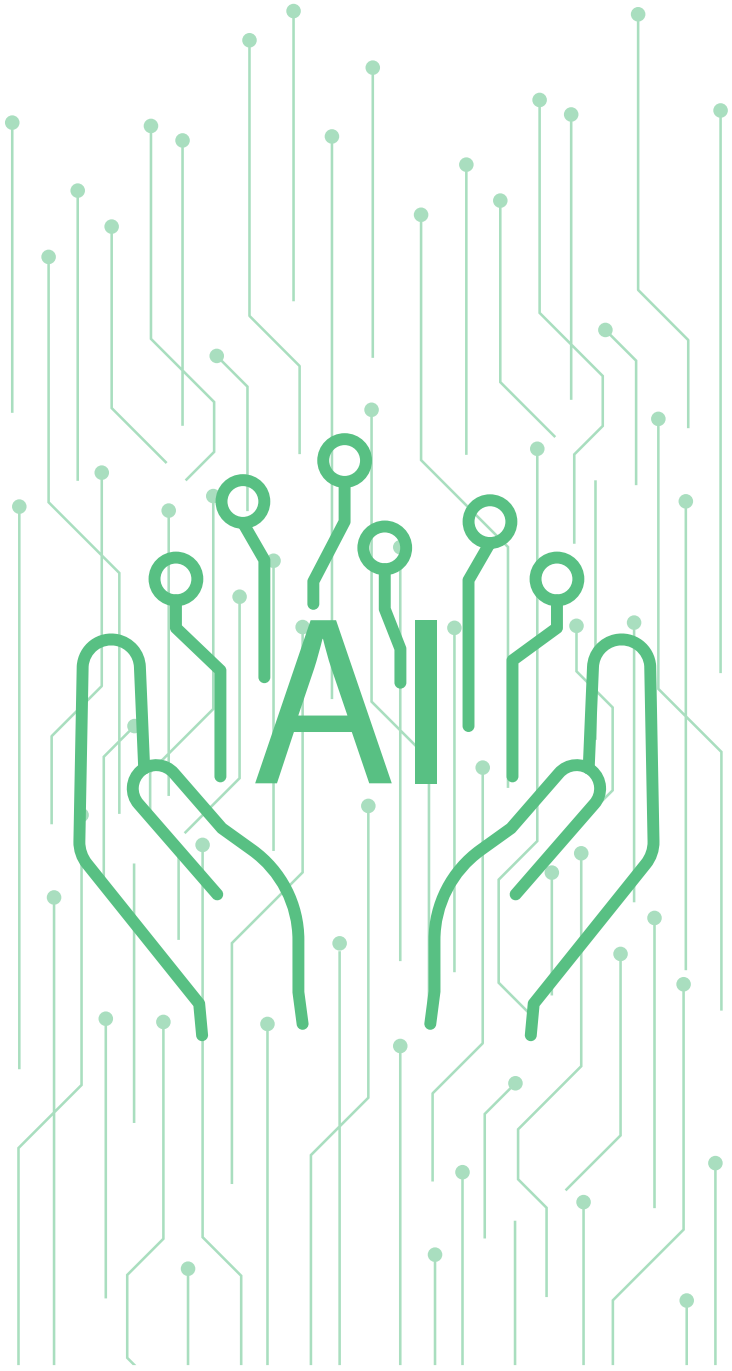
[12] Graduate STEM Fellows in K-12 (GK-12) Education Program. Undated. https://www.aaas.org/page/archives/graduate-stem-fellows-k-12-education-program

[13] National Science Foundation. Robert Noyce Teacher Scholarship Program (NSF Noyce). Program Solicitation NSF 23-586. https://new.nsf.gov/funding/opportunities/robert-noyce-teacher-scholarship-program

Examples of current **Noyce** projects supporting rural schools include: *Enhancement of Mathematics and Science Teachers in Rural Schools* (NSF 1950255); *STEM Graduate Recruitment, Licensure, and Mentorship to Prepare Teachers for Rural Tennessee School Districts* (NSF 2049681); *Preparing Highly Effective STEM Teachers for Rural Schools* (NSF 2050497); *Developing Computer Science Master Teachers for Georgia Rural Schools* (NSF 2147890); *Cultivating Exemplary STEM Teachers for High-Need Rural School Districts* (NSF 2151058); *Developing STEM Teachers Across Rural Schools: Using STEM Outreach Programs to Build and Strengthen identity as STEM Teachers* (NSF 2243229); *Building a Pathway for Recruiting and Preparing STEM Teachers in Rural West Central Illinois* (NSF 2243323); *Building Capacity to Address STEM Educator Shortages in Rural South Dakota* (NSF 2243410); and *Energizing STEM Teaching Across Rural Schools* (NSF 2243433).

The Tribal Colleges and Universities Program (TCUP) provides awards to federally recognized Tribal Colleges and Universities, Alaska Native-serving institutions, and Native Hawaiian-serving institutions to promote high quality STEM education, research, and outreach. Most recently, TCUP has a track called the **TCUP Secondary and Elementary Teachers of STEM (TSETS)**, which was modeled after the successful RSI program. TSETS supports in-service professional development in STEM disciplinary or STEM education content and/or research for K-12 STEM teachers in the relevant service area. "Examples of project activities include, but are not limited to, professional development involving seminar series and engagement in STEM instruction and content during the academic year, structured series of summer intensive workshops and trainings, and summer research opportunities".[14]

Two awards recently funded were: *Tribal Steppingstones in Educational Transformative STEM: A TCU-Led Secondary and Middle School Teachers Mathematics Networking Strategy* (NSF 2243183) and *E Kukulu Ke Kahua a Paa: Build the Foundation Until Firm* (NSF 2243371).

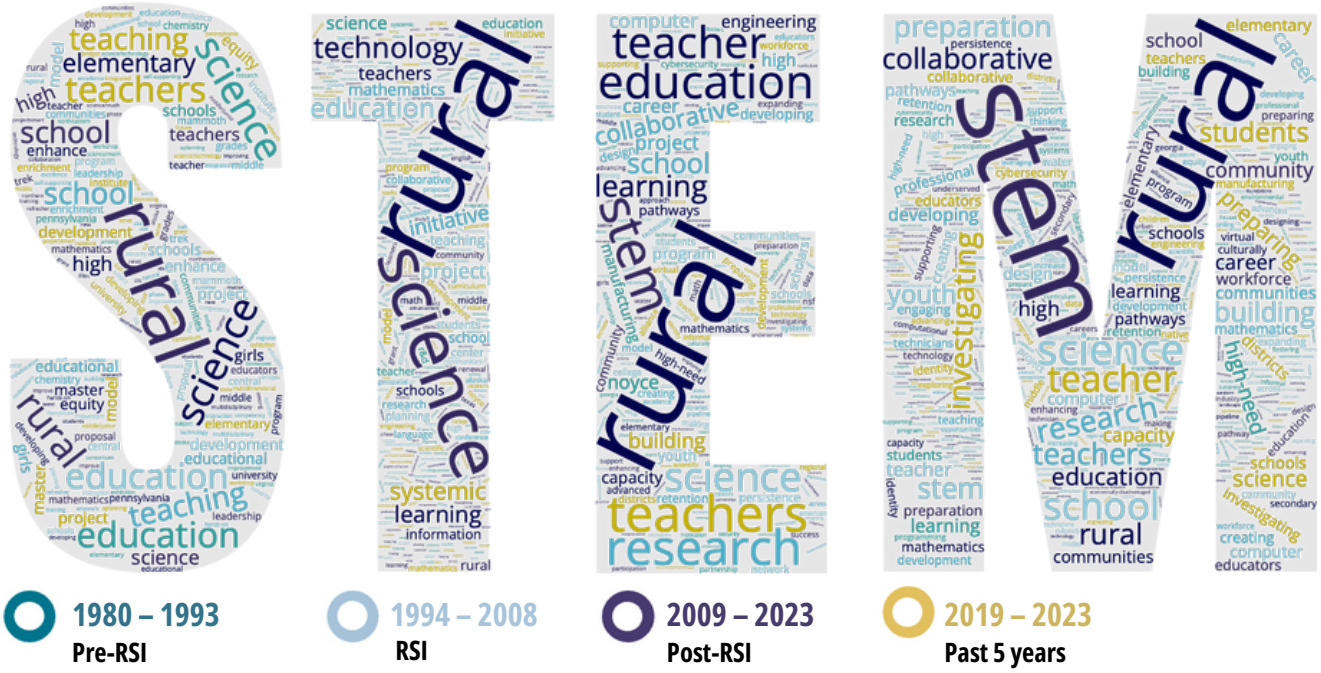


[14] National Science Foundation. The Tribal Colleges and Universities Program (NSF TCUP). Program Solicitation NSF 21-595. https://new.nsf.gov/funding/opportunities/tribal-colleges-universities-program-tcup

Demographic statistics for rural students in NSF-supported activities over time were not readily available regarding students reached and served. A review of the NSF award database provides a showcase of NSF investments in the impact and delivery of innovative STEM opportunities for rural school districts and how NSF has provided pathways to STEM career development for rural K–12 students over the past 20+ years. Figure 7 displays a visual representation of the most salient topics and foci across time periods that emerged from this review.

Figure 7

Salient topics and foci in rural STEM education across time periods



Note: Word clouds were generated by a web-based program word cloud generator, using NSF award titles across four specific time periods (Pre-RSI 1980 – 1993), (RSI 1994 – 2008), (Post-RSI 2009 – 2023), and within the (Past 5 years 2019 – 2023).

3.1 Historical Snapshot of Student Engagement

A review of trends from a historical perspective revealed important information about which organizations were the primary leads for projects supporting K–12 student participation in NSF activities. The preliminary analysis revealed the following historical patterns across three key phases: Pre-RSI, RSI and Post-RSI.

- During the Pre-RSI phase, rural K–12 students were reached and served via NSF projects led by informal science professionals with some connection to formal settings and the goal of helping to develop, inspire, and sustain interest in STEM. Examples of informal science projects accessible to preschool students during this time include:
    - *Interactive Science Exhibits for Preschool Children* (NSF 7919038; Organization: Museum of Science and Industry)
    - *Mother Goose Asks "Why?" A Science and Literature Program for Parents and Caregivers of Children 0–6* (NSF 9453817; Organization: Vermont Center for the Book)
    - *Preschool Science and Math Resource Project* (NSF 9453811; Organization: Please Touch Museum)
- The RSI phase largely reached and served K–12 students via school-based projects led by localeducation agencies or school districts, local ommunity colleges, and Minority-Serving Institutions (MSIs) supporting rural communitie

NSF-funded projects during this phase also connected with statewide reform activities to help close the achievement/performance gap. Examples of RSI projects include:

- *Michigan Rural Systemic Initiative (MiRSI) Comprehensive Regional Plan for Systemic Reform in Mathematics, Science, and Technology* (NSF 0000352; Organization: Cheboygan Otsego Presque graphicIsle Intermediate School District)
- *Cankdeska Cikana Community College Rural Systemic Initiative* (NSF 0086158; Organization: Cankdeska Cikana Community College)
- *Coastal Rural Initiative (CRSI)* (NSF 9812487; Organization: Fayetteville State University)
- *Rural Systemic Initiatives in Science, Mathematics, and Technology Education –RSI: Fort Peck Community College Rural Systemic Initiative* (NSF 0134608; Organization: Fort Peck Community College)

- The Post-RSI phase of NSF projects led by IHEs to benefit rural K–12 students addressed national issues of STEM instructional quality and student participation gaps due to access and resource issues. Examples include:
    - *Energizing STEM Teaching across Rural Schools Schools* (NSF 1557378; Organization: Juniata College)
    - *Effectively Delivering Networking and Cybersecurity Education in a Rural Environment* (NSF 1700632; Organization:North Arkansas College)
    - *Strengthening Mathematics Instructions for Elementary & Middle Schools* (NSF 1852942; Organization: Texas A&M University)
- The current expanded partnership phase of largely IHE-led projects with direct participation of K–12 students is building on prior best practices with greater attention to STEM workforce needs involving a wider group of diverse stakeholders/partners/collaborators as both designers and implementers of student activities. Examples include:
    - *Enhancing the Independent Mechatronics Technical Curriculum and Creating a New Pathway from Rural High Schools into Mechatronics Careers* (NSF 2037491; Organization: South Central College)
    - *Engaging K–12 Teachers to Help Build a Cybersecurity Workforce Pipeline* (NSF 2055253; Organization: Forsyth Technical Community College)
    - *K-12 CS Pathways for Rural and Tribal Communities* (NSF 2318354; Organization:College of Saint Scholastica)

The **TCUP** program, for example, has been successful in building capacity for STEM instruction at colleges serving Native students, particularly American Indian students, mostly in rural areas. **TCUP** is leveraging high school–college–university partnerships to expand opportunities for American Indian rural students to prepare and pursue careers in STEM fields that are culturally significant.

One project, *Salish Kootenai College SEA-PHAGES* (NSF 1800347, is expansive in connecting precollege and postsecondary STEM participation. The SKC STEM Academy conducts outreach to area elementary, middle, and high school students to generate enthusiasm for STEM-based research and provides near-peer mentoring. High school students enrolled in the dual-credit STEM Academy gain valuable hands-on laboratory experience and participate in cutting-edge research. Survey findings indicate that students' abilities to operate in a lab and carry out research techniques increased 100-fold because of this intervention. Rural high school students who enrolled in the SKC STEM Academy as juniors, and fully participated for two years, have the potential to receive more than half of the credits necessary to earn a general science associate degree at SKC, thus increasing their likelihood of earning a degree and ultimately pursuing a career in STEM.

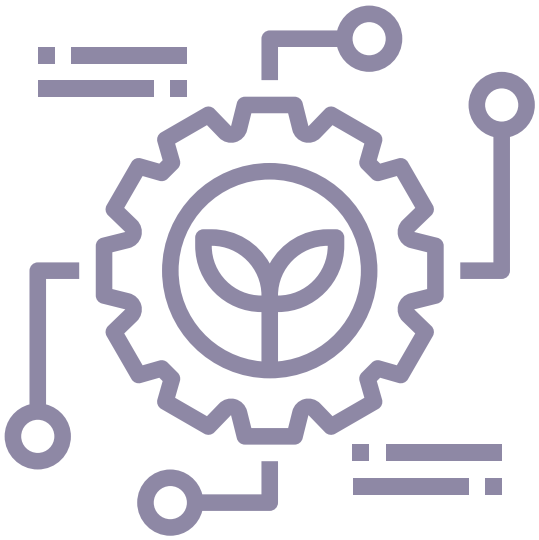
3.2 Lessons From the Pandemic

The COVID-19 pandemic has been a game-changer in many ways. Although the full range of its impacts on rural STEM education may not be known for many years, rural K–12 students are not immune to the COVID-related developmental and academic setbacks that have been observed across the nation. NSF has responded by making several key investments to investigate best practices for remote instruction, COVID-related disruptions in K–12 education, and their impact on students in rural areas. Examples of key investments:

- *A Systematic Review and Meta-Analysis on the Effectiveness of Remote Education in Math and Science* (NSF 2200883; Organization: American Institutes for Research in the Behavioral Sciences): This investment supports a meta-analysis of the past 15 years of remote STEM education. The research team plans to identify strategies with the highest probability of being impactful and best suited to support rural STEM education.

- *RAPID: Responding to a Global Pandemic—The Role of of K–12 Science Teachers* (NSF 2027397; Organization: Horizon Research Inc) and *RAPID: Science Teachers as Public Health Educators: How Has the COVID-19 Pandemic Reshaped the Roles and Experiences of K–12 Science Teachers?* (NSF 2204901; Organization: Horizon Research Inc.): The first of these projects (funded early in the pandemic) supported a survey of STEM K–12 educators to compare their teaching strategies before and after schools closed. In the second, follow-up study, the investigators assess the lingering impacts of the pandemic on STEM educators and their teaching. Although the project focuses specifically on teaching about COVID-19, its biology, and its impact on the community, it has implications beyond that topic and may yield insights into the lessons learned by educators who have had to engage their students remotely. These insights, in turn, may provide guidance for future strategies to engage and educate rural STEM students.

- *A New Generation of Broadly Accessible Remote Engineering Laboratories* (NSF 2141798; Organization: University of Washington): This investment focuses on the development of a remote computing and wireless communications laboratory course. Although the immediate audience is college students, there is potential to scale and expand this strategy to engage remote K–12 learners. Particularly exciting is the potential for coeducation of K–12 students along with college students in the same learning space.



3.3 Broader Impacts of Research Centers, Large -Scale Research, and Facilities Projects Benefitting Rural K-12 Students

One of the several areas of the merit review of the broader impacts criterion that can be addressed is the integration of research and education. Simple one-time, in-classroom outreach activities have evolved to reflect more meaningful community engagement and collaboration. For example most of the 81 sites of the National Ecological Observatory Network (NEON) are in rural areas, having place-based activities and positive impacts on rural K–12 student communities. The activities address issues that are meaningful to rural K–12 students and their communities and have been focused on understanding and forecasting the impacts of climate change, land use change, and invasive species on continental-scale ecology, and encouraging children to explore STEM careers.[15] The NEON STEM Grant Program has funded K–12 student engagement around the country, exemplified by the following five projects to leverage the open data generated by the NEON.[16]

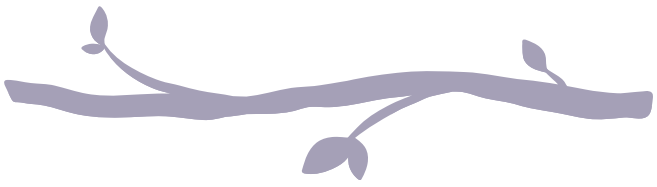
A brief description of some of the funded projects in 2020 include:

- *Teaching Change NEON: A Place-Based Immersive STEM Program to Connect Hawaii's Youth with NEON Open-Source Data by the Akaka Foundation for Tropical Forests, Hawaii:* The program was a year-long Advanced Placement science program that used NEON data to address a globally significant question. The program was implemented at Hilo High School and integrated two intensive field courses at the Pu'u Maka'ala Natural Area Reserve NEON.

- *Show and Tell by Ashburnham Westminster Regional Schools, Massachusetts:* This program focused on getting students excited about science through authentic research. Fourth- and fifth-grade students collected, analyzed, and shared NEON-like data to answer the question "Is the growing season changing?"

- *Puerto Rico NEON Data Jam by Forward Research, Puerto Rico: The Puerto Rico NEON DATA JAM Project* developed student STEM competencies through the analysis of scientific data provided by NEON during a one-week summer program. Approximately sixty students from underrepresented communities and six teachers investigated real community challenges using NEON data.

- *Environmental Education Programming 2020 by the North Lakeland Discovery Center, Wisconsin:* The project incorporated NEON's data from regional studies on terrestrial nesting bird populations and small mammal populations into the Discovery Center's existing K–12 education programs. The objectives were to improve data literacy, encourage critical thinking and use of the scientific method, increase students' awareness and understanding of wildlife ecology, and inspire students to make connections between their lives and the natural world.



[15] https://www.neonscience.org/impact/observatory-blog/kids-explore-science-and-technology-neon-day

[16] https://www.battelle.org/insights/newsroom/press-release-details/battelle-grants-enable-student-projects-to-learn-with-neon-data

- *Bringing NEON Data to Teachers in Title 1 Classroom by Science Buddies, nationwide:* This program developed lesson plans aligned to national standards for teachers of grades 6–8 using NEON data related to the mosquito populations. Students investigated the impact of climate change (on mosquitoes) and the implications for disease. Lesson plans are published and available to teachers.

The **Long-Term Ecological Research (LTER)** program is conducted at specific sites chosen to represent major ecosystem types or natural biomes. **LTER** recognizes the value of sustained interactions among students, teachers, and scientists, and strives to integrate LTER science with K–12 education (Figure 8). Most LTER sites conduct individual programs at the local community level, and the LTER network supports centralized approaches in support of educational initiatives. Education/Outreach goals include:

- Using LTER resources to enhance hands-on science learning for students.
- Developing long-term research sites on or near schoolyards.
- Facilitating communication among LTER scientists, formal and informal science educators, parents, and schoolteachers.
- Helping ecology educators make the best use of long-term studies and associated data sets.
- Fostering understanding of functions and changes of the earth's ecosystems, including local ones.
- Promoting outdoor, inquiry-based learning of science and its applications.
- Stimulating interdisciplinary, collaborative, and community-based science learning.
- Integrating long-term and multi-factorial studies into education reform and improvement.
- Promoting a broad understanding of long-term ecological processes and the earth's ecosystem.[17]

Figure 8

Selected Highlights About the Long-Term Ecological Research (LTER) and K-12 STEM Education

ELEMENTARY SCHOOL STUDENTS – LTER SCHOOLYARD SERIES

The Schoolyard Series is a collection of illustrated children's books designed to engage children and their families in learning about the Earth's ecosystems, both locally and internationally, through narratives that reflect the dynamic research being conducted at the National Science Foundation's LTER sites. The LTER sites comprised diverse ecosystems in the continental United States, Alaska, Antarctica and islands in the Caribbean and the Pacific.—

To learn more about the Schoolyard Series, visit: https://lternet.edu/schoolyard-book-series/

MIDDLE SCHOOL STUDENTS – ROAD TRIP: HJ ANDREWS EXPERIMENTAL FOREST LONG TERM ECOLOGICAL RESEARCH (LTER) SITE

A partnership between the University of Oregon Environmental Leadership Program, the Pacific Tree Climbing Institute, and the US Forest Service PNW Station, Canopy Connections brings forest science lessons and projects to K-12 students in the surrounding area.

To view stories of the LTER Road Trip, visit: https://lternet.edu/stories/lter-road-trip-gaining-a-new-perspective/

[17] https://lternet.edu/committees/education/

Long-term, place-based ecological programs have a unique opportunity to build collaborative relationships with local peoples, including Native Americans (e.g., four sites in Alaska), Blacks, and Hispanics (e.g., two urban sites: Minneapolis/St. Paul and Central Arizona), about common interests in environmental stewardship. These connections are customized from site to site depending on each area's demographics. One example, is the publication of the Schoolyard Ecology book series in multiple languages, including The Lost Seal, highlighted in Figure 9, published in many languages of the Far North.

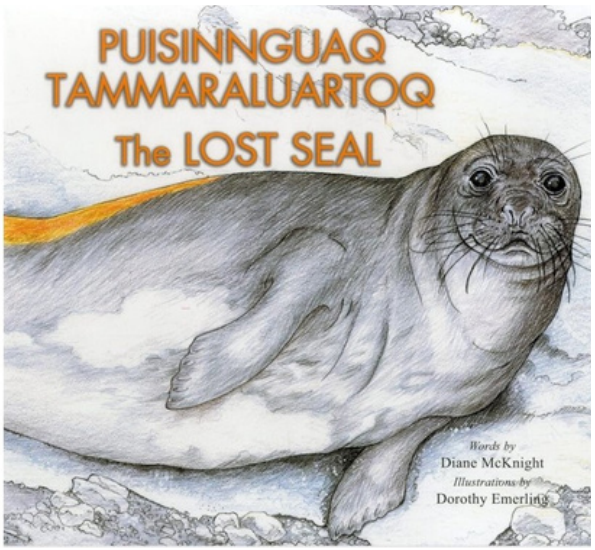
Thus, NEON- and LTER-driven projects engage rural K–12 students in meaningful and authentic research projects that are important to their communities, such as *Embedding Public Engagement with Science at Long-Term Ecological Research Sites* (NSF 1713222) and *Advancing Public Engagement with Science across the Long-Term Ecological Network* (NSF 2215187). In doing so, the projects are responsive to CEOSE's recommendation in its 2017–2018 report[18] for NSF to "[invest] in diverse community voices." Additionally, CEOSE's 2019–2020 biennial report[19] noted NEON's emphasis on broadening participation in ecological research to historically underrepresented communities through outreach and engagement activities hosted by MSIs to continue developing community inclusion. Likewise, LTER encompasses a broad network of collaborators focused on long-term ecological research that includes community engagement efforts to foster environmental literacy in diverse communities.

An underused engagement practice noteworthy to mention, especially for rural school districts, are the **Research Experiences for Teachers (RET)** and the **Research Assistantship for High School Students (RAHSS)** programs.

These funding mechanisms have been in place for many years and have served countless high school students and teachers across the country. With the advent of Zoom and other remote communications technologies and increasing focus on "dry lab" and computational approaches in all STEM disciplines, it has become increasingly feasible to engage rural students and teachers in authentic research experiences by leveraging RAHSS and RET awards and supplements.

Figure 9

The Lost Seal

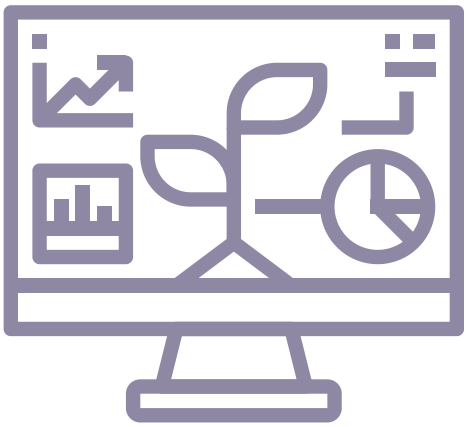


Note: *The Lost Seal*. Adapted from McKnight, D. (2016). The lost seal (D. Emerling, Illus.). Taylor Trade Publishing.

[18] Committee on Equal Opportunities in Science and Engineering. 2017-2018 Biennial Report to Congress: Investing in Diverse Community Voices. 2019. https://new.nsf.gov/od/oia/ceose

[19] Committee on Equal Opportunities in Science and Engineering. 2019-2020 Biennial Report to Congress: Making Visible the Invisible–Bold Leadership Actions. 2021. https://new.nsf.gov/od/oia/ceose

For example, the "High School Students, Undergraduate, and Post-Baccalaureate Scholars Funding Opportunities" (NSF 101) points to two opportunities for NSF-supported principal investigators (PIs) to work with high school students through supplemental awards. **The High School Student Research Assistantships (MPS-High)** (NSF 22-041) supplemental grant aims to foster interest in mathematics and physical sciences for high school students. This grant is generally under $6,000 per student and should be submitted by a PI. **The Research Assistantship for High School Students (RAHSS)** (NSF 23-145) is a supplement for PIs with an active grant from the Directorate for Biological Sciences and aims to foster interest in pursuing biological sciences. This grant is generally less than $6,000 per student. More recently, the Foundation announced the **High School Student Research Assistantships in the Social, Behavioral and Economic Sciences (SBE-High)**, (NSF 23-111). The RET is offered as a supplement opportunity to the **Research Experience for Undergraduates (REU)** program, (NSF 23-601), with Dear Colleague Letters published periodically by various programs reminding proposers to consider this impactful opportunity. Moreover, these local high school opportunities are available in all geographic locations regardless of the scale of the research award.



The Directorate for the Biological Sciences (BIO), for example, is supporting the University of North Dakota with RET and REU Site awards: *Genes and the Environment: Research Experiences for Undergraduate from Rural and Tribal Colleges* (NSF 2244080) and *Genes and the Environment: Research Experiences for Teachers from Tribal and Rural Schools* (NSF 2341459).

3.4 Pathways to and Tools for STEM Career Development

The career development of STEM talent in rural schools and communities is becoming more innovative and mutually beneficial to the nation as rural school districts become legitimate partners with IHEs and career scientists across the STEM disciplines. Moreover, NSF has transitioned from a pipeline approach to STEM career development to framing multiple opportunities to prepare for and pursue a career in STEM fields (Figure 10). In the pipeline perspective, NSF K–12 programs are focused on attitudinal-driven strategies around STEM and supporting retention strategies to stay in the pipeline, especially during critical points of transition. Strategies included after-school programs for sustaining interest in math and science among elementary school students, enrichment and motivational experiences of bringing scientists into the classroom in the middle school years, and STEM experiential programs for high school students. Over time the emphasis on critical transition to prevent leaks in the pipeline was revisited to focus on a more aspirational perspective of the various paths to pursuing STEM careers (sometimes called the “braided river” approach).

The expertise of both the informal and formal K–12 STEM communities is helping NSF to promote transformative strategies for integrating culturally inclusive, gender equity-driven, and adaptive design approaches for the meaningful and authentic participation of K–12 students in STEM activities. For illustrative purposes, two examples highlighting the importance of rural STEM education are included as follows:

The 2018 Rural Informal STEM Conference (RISC), funded by NSF, was the first of its kind to bring together key innovators and experts in rural STEM education outside of formal school to address the main question, "What can we learn from recent work in rural informal STEM education that will help us to create more, as well as more effective, scalable pathways for the future?" (Kastelein et al., 2018, p. 3).

Figure 10

Opportunities for K-12 STEM Engagement

Note: Opportunities for K-12 STEM engagement designed to help to prepare students for a career in STEM include, project-based learning, science & engineering fairs, research projects, community projects, dual enrollment, and STEM clubs.

Key insights from the conference report are shared as follows:

Promising practices in equity and inclusion include: expecting that people in rural places will self-identify in multiple ways so that a "community" may not be as simple as a geographical town or municipality; seeing STEM knowledge and learning opportunities in everyday activities and occupations within communities; avoiding a "savior mentality" by listening to what communities want and are already doing; and ceding a significant degree of control to communities as programs unfurl.

Also, it is important to know how a community may view people "from away," and to recognize that a STEM-based career may involve a wrenching move away from a rural home community (Kastelein et al., 2018, p. 2).

Building community support is likely to be a multi-year process of trust-building and co-design. STEM programs are likely to gain more community support if they involve not just youth but families, community members, schools, and industry in STEM programs. Helping communities and local businesses to see the STEM already in their work can make STEM career opportunities and pathways be seen as attractive and achievable (Kastelein et al., 2018, p. 2).

There are many efforts such as the *STEM Excellence and Leadership Program* (NSF 1713123) funded to provide access to opportunity within one's community and open windows to STEM pathways. Table 1, adapted from Lakin et al., 2022, "Nurturing STEM Talent in Rural Settings," shows how the STEM Excellence project (Figure 11) focused on the needs of rural schools and applied evidence-supported strategies to promote STEM access, the development of expertise, and early interest in STEM careers.

Research supports a combination of essential approaches to promote STEM career development in rural school districts, including "focusing on place-based instruction, honoring student strengths, and capitalizing on unique community-based assets" (Lakin et al., 2021, p. 25). Additionally, the focus on digital solutions has increased in support for K–12 teaching and learning experiences since the COVID-19 pandemic. Proponents of online and hybrid learning have stressed that "leveraging digital tools and increased resources will help diverse students preserve and persist in STEM courses and programs, and eventually in the [STEM] field" (Mangahas et al., 2022, p. 35). This observation highlights the importance of high-speed internet access to ensure that all rural STEM students have access to programming that can lead to careers in STEM.

Figure 11

STEM Excellence and Leadership Program

Note. STEM Excellence and Leadership program. Over five years, *Implementing the STEM Excellence and Leadership Program to Understand the Role of Local Agency in Broadening high-Potential, Rural Students' STEM Participation and Achievement* (NSF 1713123) reached 841 students and 40 educators in geographically diverse rural schools and produced 6 peer-reviewed publications and 11 conference proceedings.

Table 1

How the STEM Excellence Project aligns with research and rural needs

Need for rural schools	Evidence-supported strategies	STEM Excellence examples
STEM opportunities and access to the STEM pipeline	• Exposure to STEM opportunities through curriculum • Capitalization on strengths • Use of after-school time in STEM fields	• Strength-based assessment for participation • After-school opportunities • 96 hours of programming • Curriculum resources
Development of teacher expertise	Professional development related to STEM content, pedagogy, and rurality	• Professional development for evidence-supported curriculum with place-based options • Training in STEM pedagogical strategies • Support from university of personnel through site visits and feedback
Acknowledgment and use of community-based assets	Place-based learning strategies University and local expert connections	• Community members invited to discuss STEM applications in their field and provide feedback and advice on student projects • Place-based research questions and projects chosen by students • Connections to university personnel and STEM laboratories • Near-peer mentors from high school and college • Curriculum adapted to reflect local community connections and student interests

Note. Adapted from "Why Rural Matters 2023," by Lakin, J., Stambaugh, T., Ihrig., D. M., & Assouline, S.G., 2022, Nurturing STEM talent in rural settings. Spotlight on Rural Education, p. 22.

Overall, the review of NSF's policies/practices and activities revealed the following:

- a genuine commitment to agency policies and practices to be inclusive of rural communities;
- a long-standing history of varied informal and formal K–12 activities for K–12 students and teachers in rural schools;
- a directorate leading efforts to ensure that NSF has a significant rural STEM education portfolio; and
- a need for increased funding to address inequities and disparities among rural communities to continue and replicate successful practices as well as support innovative efforts that transform challenges into promising and innovative opportunities to help rural K–12 students excel in STEM education.

NSF is committed to empowering rural communities to fully participate in the scientific enterprise, including K–12 students. Overall, a review of current active NSF awards supporting rural students indicated that students are participating in a wide range of cutting-edge opportunities for strengthening STEM education and early exposure to STEM careers. They include co-designed culturally sustaining STEM learning activities, use of libraries for virtual reality learning experiences, environmental STEM identity, multidisciplinary inquiry, project-based learning (Figure 12), leveraging of digital media and mobile technology to advance computational thinking, research practice partnerships, and culturally responsive energy engineering education to name a few.

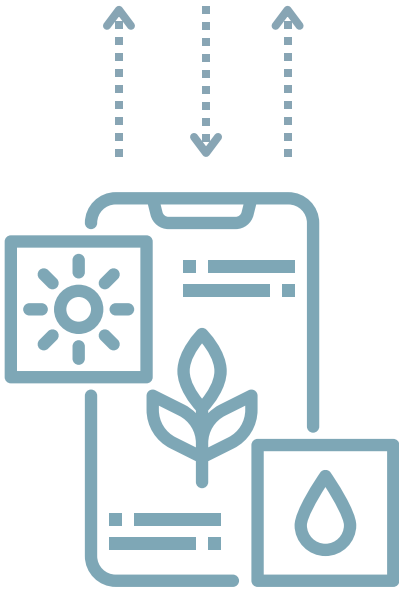
Figure 12

Place-Based Learning

PLACE-BASED LEARNING

In a place-based learning environment, teachers use hands-on challenges to integrate their curriculum into issues from within their community for students to develop practical solutions (Teton Science Schools, 2019). In STEM, place-based learning is conceptualized as an integrated approach involving student active participation and collaboration through mastery experiences (e.g., laboratory exercises, design challenges, and hands-on activities). It is designed to understand the natural and built world around us and increase math and science self-efficacy (Kloser et al., 2018).

Note. Adapted from Brown, 2021.



By leveraging investments like **NEON** and **LTER**, NSF engages rural K–12 students in authentic research experiences, working on projects that are meaningful to them and their communities, such as *LTER: Changing Disturbances, Ecological Legacies,* and the *Future of the Alaskan Boreal Forest* (NSF 2224776).

Examples of recently funded projects range from inspiring early interest in scientific careers, such as *Supporting Rural STEM Middle School Teachers and Career Counselors in the Development of Effective STEM Content and Career Development Experiences* (NSF 2300747), to promoting an early career start, such as *Creating a Sustainable Educational Pipeline for the Controlled Environmental Agriculture Workforce through a Remote Dual Credit High School to College Model* (NSF 2301183), and *Developing Cybersecurity Technicians through Expanded Pathways in Rural and Underserved Communities* (NSF 2201993) (Figure 13).

Figure 13

NSF Funded Awards of Dual Enrollment Investments

DUAL ENROLLMENT

According to the federal definition for dual enrollment by the 2015 Every Student Succeeds Act, dual enrollment is:

> **Partnerships between at least one institution of higher education and one local educational agency that allow participants to earn both postsecondary credits that transfer to the partnering IHE and credits toward a regular high school diploma.**

However, states do not share a common definition for dual enrollment and are not themselves structured identically. Student participation within dual enrollment programs is dependent upon governance structures and student requirements and vary at local and institutional levels.

NSF's Division for Undergraduate Education (DUE) has funded several awards that help create opportunities for high school students to earn college credit towards a degree and/or job ready certificate in STEM in areas such as, *Electrical Technology* (NSF 2055480), *Advanced Manufacturing* (NSF 2202182; NSF 2035556), *Electrical and Mechanical Engineering* (NSF 2037491), and *Advanced Technology* (NSF 1801062).

4.1 Current and Emerging Strategies

EDU and its Division for Research on Learning in Formal and Informal Settings (DRL) have a long history of supporting K–12 STEM education research and development efforts contextualized for K–12 students and teachers within rural communities and institutions. As the only NSF Division that focuses exclusively on K–12 and informal STEM education, DRL maintains a significant K–12 rural STEM education portfolio within the agency. In fact, DRL currently supports at least 142 active awards that focus on or include rural education and communities (see Appendix B). Many of these awards are co-funded across programs, divisions, and in some cases across the NSF Directorates. Additionally, in response to the CHIPS and Science Act, Section 10514, EDU is supporting a study on *K–12 STEM Education and Workforce Development in Rural Areas led by the National Academies of Science, Engineering, and Medicine* (NASEM). The purpose is to consider existing federal programs that support rural STEM education and workforce development and develop recommendations for federal, state, and local actions to enhance K–12 STEM rural education and workforce development.

4.2 Successful Strategies to Scale

New strategies and the advancement of existing successful strategies for K–12 STEM in rural settings will need to be aligned with the current and future perspectives of the leadership of the EDU Directorate as well as relevant innovative efforts elsewhere in the Foundation, (see Appendices C, D, and E). EDU is catalyzing opportunities for students at every level of education, especially in rural and urban America. Also, a number of the Regional Innovation Engines, funded by the TIP Directorate, will be serving rural areas with strong workforce development and education efforts in rural areas.

During the June 2023 CEOSE meeting, CEOSE commended NSF for the specific efforts, especially those supported by EDU, to address the grand STEM challenges in rural school districts.[20] Specific efforts include:

- increasing the number of STEM teachers who will work in underresourced school districts;
- ensuring that students at every junction of education have access to experiential activities that will strengthen/enhance academic preparation for the STEM career trajectory;
- supporting/establishing strong, meaningful partnerships with industries in rural communities;
- providing financial support, especially scholarships, to increase access to a STEM degree and reduce/eliminate the financial burden of earning a STEM degree;
- leveraging technology to address resource and performance disparities by helping students succeed in STEM courses/coursework and persist in the STEM pathways;
- harnessing formal and informal STEM education experiences to fill in the gaps around exposure, interests, and preparation (including using family, intergenerational, and community-based STEM events and training);
- continuing to leverage existing investments in place-based research (e.g., **NEON** and **LTER**) to engage "diverse community voices," including rural K–12 students in authentic and meaningful research;

[20] Moore (June 2023). Supporting Rural STEM Education and Research [CEOSE presentation].

- strengthening mentorship opportunities; and
- supporting knowledge mobilization to compile and share exemplary practices and strategies to improve teaching and learning in the rural context.

As noted elsewhere in this report, NSF-funded projects have leveraged the internet to reach and effectively engage rural K–12 students. The power of the internet is unquestionable, as are the limitations that ensue when rural communities do not have reliable internet access (Figure 14). NSF has begun to address this issue through a variety of funded projects, including the following:

- *Developing Rural Girls' STEM Competency and Motivation through Communicating Scientific Topics with Advanced Technology* (NSF 1657217; Organization: Maine Mathematics and Science Alliance)
- *Increasing Student Access to Industrial and Scientific Equipment Training through Authentic Remote Learning Experiences* (NSF 2055714; Organization: Community College of Allegheny County Allegheny Campus)
- *OVERCOME: Connectivity for Underserved Communities* (NSF 2044448; Organization: US Ignite, Inc.).

4.3 Future Directions for Increased Participation of K-12 Rural Students in NSF Activities

Going forward, CEOSE members suggest that NSF consider innovative approaches to rural STEM education by focusing on the following four interconnected areas mentioned in the NSF strategic plan for 2022–2026[21]. These elements are key to acknowledging the role of K–12 education in rural America as NSF addresses its themes of "missing millions"[22] and "creating opportunities everywhere."[23] Within this framework, the recent CEOSE report titled "Envisioning the Future of NSF EPSCoR" (August 2022) provides many additional salient examples for future activities and initiatives that could engage the missing millions in EPSCoR and rural states and territories. Four NSF objectives are specified in Table 2 (next page) and are linked to critical areas of focused broadening participation attention.

Figure 14

Rural Students' Access to the Internet

Consider the following fast facts on rural students' access to the internet reported in the *Condition of Education 2023* report:

- In 2019, approximately 663K students in rural areas were living in homes without internet access.
- Students living in rural areas less commonly had home access to fixed broadband internet and more commonly had mobile broadband internet access at home.
- In rural areas, 57 percent of students living in families with incomes below the poverty threshold had access to fixed broadband at home.

Note. Adapted from "Rural Students' Access to the Internet. Condition of Education 2023."

[21] The full NSF Strategic plan can be found at https://www.nsf.gov/pubs/2022/nsf22068/nsf22068.pdf

[22] The full NSB Vision 2030 report can be found at https://www.nsf.gov/nsb/publications/2020/nsb202015.pdf

[23] For more information, see the NSF FY 2024 Budget Request to Congress at https://nsf-gov-resources.nsf.gov/2023-08/NSF%20FY24%20CJ_Entire%20Rollup_web_%28ERRATA%20v4%29.pdf?VersionId=O1Um6rPm6xnLj80uA05Dm7IwxHUqScDO

Table 2

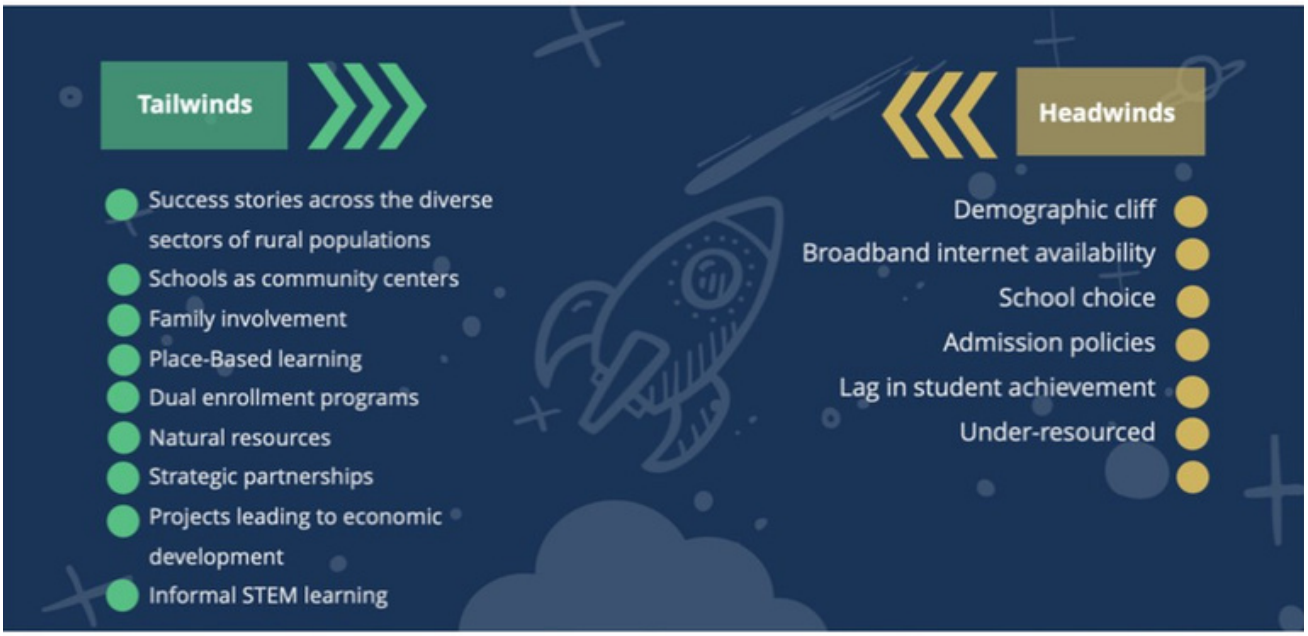
Suggested Actions for K-12 Rural STEM Education Aligned with NSF Objectives

NSF Objectives	Focused BP Attention	Suggestion Actions
Widespread STEM Literacy	**Perceptions and Perspectives**	The NSF STEM K–12 portfolio does, and must continue to, support research projects that address misconceptions about rural communities and promote the diversity of innovative perspectives from diverse populations in rural settings, including perspectives about how to eliminate systemic barriers. Engage K–12 educators and students in NSF policy development and STEM research planning activities. Continue stakeholder listening sessions with rural communities to build sustained local and/or regional ecosystems that are tailored to the diversity of populations in rural areas to ensure impactful societal benefits of K–12 education for students and their families, cultivating multiple opportunities to excel in STEM literacy.
Access to High Quality STEM Learning and Training	**Preparation and Progression**	The STEM K–12 award portfolio needs to increase its support for collaborative frameworks for large-scale change efforts to advance accessible, high-quality, inclusive STEM education for rural students. As well, teacher collaboratives in rural school districts will help ensure a well-prepared STEM teaching workforce for rural school districts who, in turn, will prepare future generations of innovators, scientists, and engineers from and for rural communities. For example, a partnership with Teach for America's Rural School Leadership Academy is encouraged. Also, consider the modeling of rural industry involvement like the 12 For Life Cooperative Education Program, which has married class-based instruction and mentoring with on-the-job training and employment opportunities in ways that increased high school graduation and postsecondary enrollment. Develop strategies to provide incentives to attract and retain rural K–12 STEM educators and administrators, including support for school-driven STEM research activities. Invest in the modernization of high school laboratories and promote access to reliable virtual research experiences. Promote explicit and intentional efforts to address intersectional impacts on academic endeavors and participation disparities in STEM education and research experiences prior to high school graduation.
Early Engagement with the Research Community	**Presence and Place-Based Participation**	NSF can enhance the intellectual merit and broader impact criteria by highlighting the value of outreach to and authentic engagement with the natural and human resources available in rural communities, particularly making more visible co-designed place-based projects for rural students and their families, as well as their local communities. Likewise, NSF can continue to support informal STEM opportunities and research in rural settings. For example, adapt the University of Pittsburgh's transformative effort to integrate a grassroots framework to build innovative IHE collaborations and partnerships involving wraparound services, K–12 support programs, and technology upgrades. Grow opportunities in education and workforce development that involve engaging early career support and mentoring for middle and high school rural students to consider and/or pursue their STEM potential.
Increased Inclusion in the STEM Workforce	**Professional Paths through K–12 Partnerships**	NSF needs to increase support for field-driven/field-specific, multi-partnership proposals to fill workforce gaps and address the needed flexibilities, including leveraging new technologies and dual enrollment programs, to improve/enhance the STEM pathways of rural students. STEM aspirations, coupled with the necessary K-12 academic preparation and achievement, enable students to stay on course for careers in STEM fields. For example, capitalize on agricultural extension partnerships with organizations such as 4-H to enhance curriculum and research-based training. Invest in growing a critical mass of rural STEM talent for emerging fields of science and engineering by promoting K-12 collaborations within and across the NSF EPSCoR jurisdictions (e.g., partnering with rural youth groups such as 4-H Clubs). Initiate broader, joint research and outreach activities with two-year colleges and MSIs to build creative/innovative K-14 pathways. Encourage local community colleges and local STEM industries to share resources and become anchors for rural STEM community engagement, education, research, and innovations.

In summary, CEOSE plans to continue to advise NSF on making more visible the support to advance and sustain high-quality teaching, place-based learning, community-driven research, and dual enrollment opportunities in rural schools by recognizing the value of rural education for contributions to workforce diversity, national security, leadership in science and engineering, and economic growth through innovation. This can be done while being astutely aware of the diversity within rural communities' assets (tailwinds) and the need for change/transformation (headwinds) for integrating STEM talent development in early, middle, and high school STEM education (Figure 15). Additionally, CEOSE will encourage continued support for informal STEM learning opportunities and research in rural settings for developing identities and curiosities in STEM and enhancing the understanding of STEM and STEM processes among learners across the life span in rural communities.

Figure 15

Headwinds and Tailwinds



References

Assouline, S. G., & Ihrig, L. M. "Implementing the STEM excellence and leadership program to understand the role of local agency in broadening high-potential, rural students' STEM participation and achievement" https://www.scientia.global/wp-content/uploads/Assouline_Ihrig/Assouline_Ihrig.pdf

Brown, M. (2021). *Evaluating STEM Field Interest and Achievement of Adolescents and faculty development in credits count.* (Evaluation Report for Ashland Community and Technical College)

Harmon, H., & Smith, K. (2012). *Legacy of the Rural Systemic Initiatives: Innovation, leadership, teacher development, and lessons learned.* Nashville, TN: Edvantia, Inc.

Kastelein, K., Allen, S., Keller, T.E., & Mokros, J. (2018). The 2018 Rural Informal STEM Conference: Final Report, Maine Mathematics and Science Alliance, https://www.mmsa.org/projects/RuralConference2018

Kettler, T., Russell, J., & Puryear, J. S. (2015). Inequitable access to gifted education: Variance in funding and staffing based on locale and contextual school variables. *Journal for the Education of the Gifted*, 38(2), 99–117. https://doi.org/10.1177/0162353215578277

Kloser, M., Wilsey, M., Twohy, K. E., Immonen, A. D., & Navotas, A. C. (2018). "We do STEM": Unsettled conceptions of STEM education in middle school STEM classrooms. *School Science and Mathematics*, 118(8), 335–347. https://doi.org/10.1111/ssm.12304

Lakin, J. M., Stambaugh, T., Ihrig, L. M., Mahatmya, D., & Assouline, S. G. (2021). Nurturing STEM talent in rural settings. *Phi Delta Kappan*, 103(4), 24–30. https://doi.org/10.1177/00317217211065823

Mangahas, A, Tate, K. J., & Harris, K. (2022). Challenges and digital solutions with STEM learning. *Journal of Online Learning Research and Practice*, 8(2).

Maryboy, N. (2022, June 16) *Bringing an Awareness to Native Voice of Ways of Knowing* [PowerPoint slides]. CEOSE Advisory Committee Virtual Meeting.

McKnight, D. (2016). *The Lost Seal* (D. Emerling, Illus.). Taylor Trade Publishing.

Moore, J. (June, 2023). *Centering the Voices of Those Often Excluded: K-12 and Informal STEM Education Research Perspectives* (CEOSE presentation).

National Center for Education Statistics. (2022). Characteristics of elementary and secondary schools. *Condition of Education.* U.S. Department of Education, Institute of Education Sciences. Retrieved October 13, 2023, from https://nces.ed.gov/programs/coe/indicator/cla

National Center for Education Statistics. (2023). Children in rural areas and their family characteristics. *Condition of Education.* U.S. Department of Education, Institute of Education Sciences. Retrieved October 13, 2023, from https://nces.ed.gov/programs/coe/indicator/lfa

National Center for Education Statistics. (2023). Enrollment and school choice in rural areas. *Condition of Education.* U.S. Department of Education, Institute of Education Sciences. Retrieved October 12, 2023, from https://nces.ed.gov/programs/coe/indicator/lcb

National Center for Education Statistics. (2023). Public high school graduation rates in rural areas. *Condition of Education*. U.S. Department of Education, Institute of Education Sciences. Retrieved October 18, 2023, from https://nces.ed.gov/programs/coe/indicator/lba

National Center for Education Statistics. (2023). Public school enrollment. *Condition of Education*. U.S. Department of Education, Institute of Education Sciences. Retrieved October 18, 2023, from https://nces.ed.gov/programs/coe/indicator/cga

National Center for Education Statistics. (2023). Rural students' access to the internet. *Condition of Education.* U.S. Department of Education, Institute of Education Sciences. Retrieved October 18, 2023, from https://nces.ed.gov/programs/coe/indicator/lfc

National Science Foundation. (2023). Proposal and Award Policies & Procedures Guide (PAPPG). Retrieved October 12, 2023, from https://nsf-gov-resources.nsf.gov/2022-10/nsf23_1.pdf

National Science Foundation FY 2022–2026 Strategic Plan. Alexandria, Virginia, 2022. Retrieved October 12, 2023, from www.nsf.gov/about/performance/strategic_plan.jsp

Ucko, David. (2010). *NSF influence on the field of informal science education. Informal Science.* https://www.informalscience.org/sites/default/files/NSFImpactonISE.pdf

U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), various years, 2009–19 Science Assessments.

U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), various years, 1990–2022 Mathematics Assessments.

Appendix A

Active Pre-K Awards Related to Rural STEM Education

Award Number	Title	NSF Org	Program	Organization
1811356	Teaching Together: Engaging Parents and Preschoolers in STEM Activities & Academic Conversations	EDU/DRL	AISL	The University of Texas Health Science Center at Houston
1823489	Exploring the relation between non-spatial skills and mental rotation from infancy to preK	SBE/BCS	Developmental Science	Cornell University
1906409	Collaborative Research: Head Start on Engineering: Developing a Learning Community to Study and Support Family-level Interest in Engineering	EDU/DRL	AISL	TERC, Inc
1906433	Collaborative Research: Head Start on Engineering: Developing a Learning Community to Study and Support Family-level Interest in Engineering	EDU/DRL	AISL	Oregon Museum of Science and Industry
1907904	Young Mathematicians: Expanding an Innovative and Promising Model Across Learning Environments to Promote Preschoolers' Mathematics Knowledge	EDU/DRL	Discovery Research K-12	Education Development Center
1920545	Early Emergence of Socioeconomic Disparities in Mathematical Understanding	EDU/DRL	Discovery Research K-12, ECR-EDU	University of Pittsburgh
1920660	Collaborative Research: Social Influences of Math Learning	EDU/DRL	ECR-EDU	University of California-Irvine
1920725	Collaborative Research: Social Influences of Math Learning	EDU/DRL	ECR-EDU	Boston College
1933698	Engaging Preschoolers in Data Collection and Analysis to Promote Computational Thinking in Mathematics: Exploring a Technology-Based Approach	EDU/DRL	STEM+C, CSforAll	Education Development Center
2005594	Investigating the Impact of Head Start Family Interactions on Childrens STEM Process Skills during Family Events at Two Science Centers	EDU/DRL	AISL	Sciencenter
2005975	Fostering Joint Parent/Child Engagement in Preschool Computational Thinking by Leveraging Digital Media, Mobile Technology, and Library Settings in Urban and Rural Communities	EDU/DRL	ITEST, AISL	WGBH Educational Foundation
2010547	Implementation and Efficacy Study of Preschool Math Activities for Numeracy	EDU/DRL	Discovery Research K-12	Wesleyan University
2031394	Culturally Relevant Robotics: A Family and Teacher Partnership for Computational Thinking in Early Childhood	EDU/DRL	CSforAll	University of Tennessee Knoxville
2042489	Innovating Developmental Science with an Online, Scalable Meta-Science Platform for Investigating Cognitive Development During Early Childhood	SBE/BCS	Human Networks & Data Sci Res, Developmental Sciences	University of Texas at Dallas
2047194	CAREER: Cultivating Curiosity to Promote Learning and Discovery	SBE/BCS	Developmental Sciences	Arizona State University

2048883	Transforming Preschoolers' Spatial Orientation: Leveraging New Technologies for Learning in Early Childhood Classrooms and at Home	EDU/DRL	ITEST	Education Development Center
2049767	Investigating environmental identity development among children in rural Alaska Native communities through intergenerational, culturally responsive community science programming	EDU/DRL	ITEST	WGBH Educational Foundation
2101169	Bilingualtek: An integrated science-language approach for Latinx preschoolers	EDU/DRL	Discovery Research K-12	University of North Carolina Greensboro
2115463	Diálogos: Harnessing Latinx Community Cultural Wealth to Support Executive Function in Early Childhood through Family Engineering Experiences	EDU/DRL	AISL	TERC, Inc
2146669	Effects of multisensory input on numerical representations of diverse-SES preschoolers	SBE/BCS	Developmental Sciences	Utah State University
2148777	Enhancing Early Childhood Educators' Knowledge of Computer Science and Engineering Concepts to Spark Young Children's Early Interest in STEM Careers	EDU/DRL	ITEST	University of Southern California
2200523	CAREER: A longitudinal study of the emotional and behavioral processes of Environmental Identity Development among rural and non-rural Alaskan children	SBE/BCS	Developmental Sciences	South Dakota State University
2201673	Collaborative Research: Bridging Preschool and Kindergarten Science: Exploring Play-based Engagement with Scientific and Engineering Practices in Early Learning Environments	EDU/DRL	ITEST, Discovery Research K-12	Bowdoin College
2201674	Collaborative Research: Bridging Preschool and Kindergarten Science: Exploring Play-based Engagement with Scientific and Engineering Practices in Early Learning Environments	EDU/DRL	Discovery Research K-12	Maine Mathematics and Science Alliance
2201960	Collaborative Research: A Multi-Lab Investigation of the Conceptual Foundations of Early Number Development	EDU/DRL	ECR-EDU	University of California-San Diego
2201961	Collaborative Research: A Multi-Lab Investigation of the Conceptual Foundations of Early Number Development	EDU/DRL	ECR-EDU	Trustees of Boston University
2201962	Collaborative Research: A Multi-Lab Investigation of the Conceptual Foundations of Early Number Development	EDU/DRL	ECR-EDU	Boston College
2201963	Collaborative Research: A Multi-Lab Investigation of the Conceptual Foundations of Early Number Development	EDU/DRL	ECR-EDU	University of Illinois at Urbana-Champaign
2201964	Collaborative Research: A Multi-Lab Investigation of the Conceptual Foundations of Early Number Development	EDU/DRL	ECR-EDU	Temple University
2201965	Collaborative Research: A Multi-Lab Investigation of the Conceptual Foundations of Early Number Development	EDU/DRL	ECR-EDU	University of Missouri-Columbia
2201966	Collaborative Research: A Multi-Lab Investigation of the Conceptual Foundations of Early Number Development	EDU/DRL	ECR-EDU	Johns Hopkins University
2201967	Collaborative Research: A Multi-Lab Investigation of the Conceptual Foundations of Early Number Development	EDU/DRL	ECR-EDU	Skidmore College
2201968	Collaborative Research: A Multi-Lab Investigation of the Conceptual Foundations of Early Number Development	EDU/DRL	ECR-EDU	University of Pittsburgh

2209594	Investigating environmental identity development among children in rural Alaska Native communities through intergenerational, culturally responsive community science programming	EDU/DRL	ITEST	South Dakota State University
2213711	Promoting Math in Young Children: Leveraging pediatric clinics to reach underrepresented children in rural communities	EDU/DRL	AISL	Stanford University
2222218	Examining and Promoting Math Engagement for Families with Young Children	EDU/DGE	ECR:BCSER Postdoctoral Fellowships, ECR-EDU	Boston College
2224247	Collaborative Research: Promoting Equity in Early Mathematics Education for Latinx Children in Head Start Programs	EDU/DRL	ITEST	TERC, Inc.
2224248	Collaborative Research: Promoting Equity in Early Mathematics Education for Latinx Children in Head Start Programs	EDU/DRL	ITEST, Discovery Research K-12	New York University
2237902	CAREER: Investigating young children's opportunities to learn mathematics in early childhood classrooms	EDU/DRL	Discovery Research K-12	San Diego State University Foundation
2247807	Over-engaged parenting and science achievement in early childhood	EDU/DRL	Discovery Research K-12, ECR-EDU	Yale University
2300233	Developing an Early Mathematics Intervention for Children with Disabilities in the Home Learning Environment	EDU/DRL	Discovery Research K-12	University of Oregon Eugene
2300676	Enhancing Early Childhood Educators' Reflective Practice and Content Knowledge to Increase Children's Capacity for Science Talk	EDU/DRL	Discovery Research K-12	University of Nebraska-Lincoln
2301009	Improving Flexible Attention to Numerical and Spatial Magnitudes in Young Children	EDU/DRL	ECR-EDU	University of Dayton
2301245	Collaborative Research: Promoting Math Skills through Playful Communication in the Home Environment	EDU/DRL	ECR-EDU	University of Maryland, College Park
2301246	Collaborative Research: Promoting Math Skills through Playful Communication in the Home Environment	EDU/DRL	ECR-EDU	Harvard University
2309657	Examining Potential Causal Connections and Mechanisms between Children's Block Play and Mathematics Learning	EDU/DUE	Discovery Research K-12, ECR-EDU	University of Oregon Eugene
2322850	Development of Attention in Preschool Children	SBE/BCS	Developmental Sciences	Yale University
2403725	Vocabulary and Reading Difficulties in Preschool and 1st Grade and their Consequences for Mathematics and Science Achievement in 1st-5th Grade	EDU/DRL	ECR-EDU	SUNY at Albany
2405548	Collaborative Research: A Multi-Lab Investigation of the Conceptual Foundations of Early Number Development	EDU/DRL	ECR-EDU	Indiana University
2410889	Improving Flexible Attention to Numerical and Spatial Magnitudes in Young Children	EDU/DRL	ECR-EDU	Indiana University

Appendix B

Active EDU/DRL Awards Related to Rural STEM Education

Award Number	Title	Program	Organization
1657553	Improving the Pipeline for Rural and American Indian Students Entering Computer Science Via Storytelling	ITEST	Montana State University
1811506	Enhancing the Capacity for Rural Libraries to Engage the Public in Drought Science, Monitoring, and Adaptation	AISL	Oklahoma State University
1850447	Strategies: Understanding Weather Extremes with Big Data: Inspiring Rural Youth in Data Science	ITEST	Education Development Center
1906084	Collaborative Research - STAR Library Network Phase 3: Enhancing STEAM Equity and Learning Opportunities in Libraries and Their Rural Communities	AISL	American Library Association
1906172	Enhancing Learning Opportunities in Libraries of Rural Communities	AISL	Space Science Institute
1906368	Establishing a learning network to connect museums, scientists and rural communities to discuss scientific information to inform transdisciplinary problem-solving.	AISL	University of Pittsburgh
1906774	Establishing a learning network to connect museums, scientists and rural communities to discuss scientific information to inform transdisciplinary problem-solving.	AISL	Carnegie Institute
1933491	Sociocultural Approach to Integrating Computational Thinking and Data Analysis into an Online Citizen Science Program Linking Rural Educators in Maine, Mississippi, and Alabama	STEM+C, ITEST	Maine Mathematics and Science Alliance
1933717	Research on the Integration of Science, Engineering, Mathematics, and Computational Thinking in Rural Elementary Teacher Professional Development and Effects on Practice	STEM+C	Longwood University
1942500	CAREER: Job Embedded Education on Computational Thinking for Rural STEM Discipline Teachers	CSforAll, Discovery Research K-12	Utah State University
1948709	Collaborative Research: STEM Career Connections: A Model for Preparing Economically-Disadvantaged Rural Youth for the Future Workforce	ITEST	University of Colorado at Boulder
1949299	Collaborative Research: STEM Career Connections: A Model for Preparing Economically-Disadvantaged Rural Youth for the Future Workforce	ITEST	Utah State University
1949322	Collaborative Research: STEM Career Connections: A Model for Preparing Economically-Disadvantaged Rural Youth for the Future Workforce	ITEST	University Corporation for Atmospheric Research
1949454	Developing STEM Identity in Rural Audiences through Community-based Engineering Design	ITEST	North Carolina State University
2005734	Engaging Rural Youth in Multidisciplinary Inquiry through Archaeology	AISL	SUNY at Binghamton
2005975	Fostering Joint Parent/Child Engagement in Preschool Computational Thinking by Leveraging Digital Media, Mobile Technology, and Library Settings in Urban and Rural Communities	ITEST, AISL	WGBH Educational Foundation

2006263	Collaborative Research: Synchronous Online Video-Based Development for Rural Mathematics Coaches	Discovery Research K-12	University of Rochester
2006353	Collaborative Research: Synchronous Online Video-Based Development for Rural Mathematics Coaches	Discovery Research K-12	Regents of the University of Idaho
2010086	Preparing Teachers to Design Tasks to Support, Engage, and Assess Science Learning in Rural Schools	Discovery Research K-12	University of Colorado at Boulder
2010256	An Interdisciplinary Approach to Supporting Computer Science in Rural Schools	Discovery Research K-12	CodeVA
2031175	Inclusive Data Science Education for Rural Elementary Students: A Research Practice Partnership for Agile Learning	CSforAll	Clemson University
2031382	Collaborative Research: Supporting Rural Paraprofessional Educators and their Students with Computer Science Professional Learning and Expansively Framed Curriculum	CSforAll	Utah State University
2031404	Collaborative Research: Supporting Rural Paraprofessional Educators and their Students with Computer Science Professional Learning and Expansively Framed Curriculum	CSforAll	Stanford University
2045561	CAREER: Engaging Rural Students with Next Generation Physiological Interfaces	CSforAll, ITEST	University of Alabama Tuscaloosa
2049767	Investigating environmental identity development among children in rural Alaska Native communities through intergenerational, culturally responsive community science programming	ITEST	WGBH Educational Foundation
2101383	Developing the Pedagogical Skills and Science Expertise of Teachers in Underserved Rural Settings	Discovery Research K-12	Brigham Young University
2101590	Supporting the Implementation of Scientific Modeling Instruction in High School Chemistry and Biology in Rural Schools	Discovery Research K-12	North Carolina State University
2115488	Examining the Efficacy of a Co-Designed Culturally Sustaining STEM Learning Ecosystems Model for Youth, Their Families, and Informal Educators in Rural Communities	AISL	The High Desert Museum
2115860	The Blue Whales Project: Engaging audiences in adaptation related science content through a giant screen film and educational activities in science centers and rural libraries	AISL	California Science Center Foundation
2116046	Utilizing the Library System and Virtual Reality Learning Experiences to Engage Rural and LatinX Communities in Polar Research	Polar Special Initiatives, AISL	University of Wisconsin-Madison
2126060	Institute for Measurement Methods in Rural STEM Education	ECR:BCSER	University of South Carolina at Columbia
2146613	Using drone technology, communal motivation, and strength-based approaches to engage middle school female students from rural areas in STEM	ITEST	CAST, Inc.
2148345	Bolstering STEM Pathways for Students in Rural New England Through a Comprehensive, Multi-Year Learning Community	ITEST	New Hampshire Academy of Science, Inc.
2148680	Engaging Rural Students in Artificial Intelligence to Develop Pathways for Innovative Computing Careers	ITEST	North Carolina State University
2201249	Investigating how combining intensive professional development and modest support affects rural, elementary teachers' science and engineering practice	Discovery Research K-12	University of North Dakota Main Campus

2201393	Collaborative Research: Fostering Virtual Learning of Data Science Foundations with Mathematical Logic for Rural High School Students	CSforAll, Discovery Research K-12	Texas Tech University
2201394	Collaborative Research: Fostering Virtual Learning of Data Science Foundations with Mathematical Logic for Rural High School Students	CSforAll, Discovery Research K-12	University of Florida
2209594	Investigating environmental identity development among children in rural Alaska Native communities through intergenerational, culturally responsive community science programming	ITEST	South Dakota State University
2213711	Promoting Math in Young Children: Leveraging pediatric clinics to reach underrepresented children in rural communities	AISL	Stanford University
2213919	STEM Pathways for Rural Youth: Developing STEM Identity Through the Outdoors	AISL	CAST, Inc.
2215382	Engaging Rural, Latinx Youth in an After School Program That Integrates Design Thinking, Making and Math	AISL	TERC Inc
2219418	Computer Science for Appalachia: Expanding a Research-Practice Partnership to Integrate Computer Science and Literacy in Rural East Tennessee Schools	CSforAll	University of Tennessee Knoxville
2236832	Conference: Annual Rural STEM Learning Summit	AISL	Arizona Technology Council Foundation
2246988	Collaborative Research: Exploring the Landscape of Rural Mathematics Education	Discovery Research K-12	University of Rochester
2246989	Collaborative Research: Exploring the Landscape of Rural Mathematics Education	Discovery Research K-12	Regents of the University of Idaho
2246990	Collaborative Research: Exploring the Landscape of Rural Mathematics Education	Discovery Research K-12	Horizon Research Inc
2300532	Improving Rural Middle Grades Mathematics Instruction through a Statewide Teacher-Researcher Alliance	Discovery Research K-12	Boise State University
2300747	Supporting Rural STEM Middle School Teachers and Career Counselors in the Development of Effective STEM Content and Career Development Experiences	Discovery Research K-12	University of South Carolina at Columbia
2313972	Informal Biodiversity Education Models for Rural and Tribal Youth	AISL	University of Nebraska-Lincoln
2318339	Agricoding: Broadening Rural Participation in Computer Science	CSforAll	Katabasis, Inc.
2333959	CAREER: Equity Focused Elementary Mathematics: Creating Virtual Mathematics Communities in Rural Georgia	Discovery Research K-12	University of Georgia Research Foundation Inc

Appendix C

Active EDU/DUE Awards Related to Rural STEM Education

Award Number	Title	Program	Organization
1136403	TTU STEM Majors for Rural Teaching (TTU-SMaRT) - Noyce Scholarship Program	Noyce	Tennessee Technological University
1136406	Pipeline for Excellent Rural Teaching	Noyce	North Dakota State University Fargo
1660721	Preparing Secondary Teachers of Mathematics and Science in Rural Districts	Noyce	Morehead State University
1741744	Improving the Success of STEM Undergraduate Students in a Rural Community: Learning with Emphasis on Academics, Developmental Experiences, and Research in STEM	S-STEM	Quincy University
1741820	Improving STEM Education in a Rural Area	S-STEM	University of Houston - Victoria
1742496	Closing the STEM Labor Gap through a Path to Graduation for Low Income, Rural Students	S-STEM	University of Arkansas
1758395	Preparing a Community of Outstanding STEM Teachers for Rural and Urban Northeast Texas	Noyce	Texas A&M University-Commerce
1758406	Supporting the Preparation of Science and Mathematics Teachers in Rural South Texas	Noyce	The University of Texas Rio Grande Valley
1758433	Robert Noyce Teacher Scholarship Program for Education of Secondary STEM Teachers in Rural Virginia	Noyce	James Madison University
1758443	Preparing STEM Teachers for Urban and Rural School Districts in Northwest Georgia	Noyce	Berry College
1758447	Producing STEM Teachers for Urban and Rural Schools in Kentucky	Noyce	University of Kentucky Research Foundation
1758484	Rural Appalachian Leaders and Local Youth for STEM	Noyce	Ohio University
1758496	NebraskaSTEM: Supporting Elementary Rural Teacher Leadership	Noyce	University of Nebraska-Lincoln
1833694	Breaking the Cycle through Computational Physics: Preparing West Virginia's Rural, First-Generation College Students for the Careers of the Future	S-STEM	West Virginia University Research Corporation
1852690	Inspire and Prepare Noyce Scholars to Teach in Rural Environments	Noyce	St. John Fisher College
1852795	Implementing Novel STEM Practices in Rural Education (INSPIRE)	Noyce	University of West Alabama
1902093	Expanding Access to Cybersecurity Career Pathways for Rural Community College Students	ATE	Palm Beach State College
1929409	Creating STEM Opportunities for High-Achieving Rural Alabama Students	S-STEM	University of North Alabama
1930008	Scholarships with Integrated Academic, Mentoring, Career Development, and Wellness Supports to Increase STEM Degree Attainment of Rural Undergraduate Students	S-STEM	Wilson College
1930184	Navigating Pathways to Success: Improving Outcomes for Rural Community College STEM Scholars through Mentoring and Comprehensive Interventions	S-STEM	Cape Cod Community College
1930514	Educating Future Scientists and Mathematicians from Rural and Underserved Regions	S-STEM	Texas Tech University

1949915	Growing Highly Qualified Mathematics Teachers for a High-Need Rural Area	Noyce	Bemidji State University
1949919	Preparing Undergraduate Science Majors to Teach in High-Need Rural and Urban Schools	Noyce	SUNY College at Oneonta
1949990	Preparing STEM Teachers to Serve in High-Need, Rural School Districts	Noyce	Utica College
1950129	Building Culturally Competent STEM Teacher Leaders for Rural, High-need Schools Near the U.S. Border with Mexico	Noyce	University of Arizona
1950196	Creating Infrastructure for Computer Science Education in Rural North Louisiana	Noyce	Louisiana Tech University
1950218	Preparing STEM and Computer Science Educators for Teaching in Rural High-Need Schools in Vermont	Noyce	University of Vermont & State Agricultural College
1950255	Enhancement of Mathematics and Science Teachers in Rural Schools	Noyce	South Dakota State University
1950288	Preparing Mathematics Teacher-Leaders for Rural Schools in Minnesota and North Dakota	Noyce	Concordia College at Moorhead
1953487	Developing and Studying a Research Experience Pathway to Improve Undergraduate Life Sciences Education at a Rural Hispanic Serving Institution	HSI	New Mexico Highlands University
1955139	Water and Environmental Technology Education for Rural Small Water Systems	ATE	Clackamas Community College
2000933	Expanding Remote Delivery of Information Technologies Education in a Rural Environment	ATE	North Arkansas College
2021276	Integrating Project- and Place-based Research Experiences into General Education Courses to Increase Persistence of First-generation and Rural Undergraduates in STEM	IUSE	Morningside University
2027402	Supporting Retention and Graduation of Biology, Chemistry, and Mathematics Majors in Rural Central Louisiana	S-STEM	Louisiana State University at Alexandria
2030114	Increasing the Academic and Career Success of Alaska Native and Rural Students in Science and Math	S-STEM	University of Alaska Anchorage Campus
2030174	Increasing the Academic and Career Success of Alaska Native and Rural Students in Science and Math	S-STEM	University of Alaska Southeast Juneau Campus
2030478	STEM-relevant Civic Engagement and Service as a Foundation to Prepare Rural Undergraduates for STEM Careers	S-STEM	Morningside University
2030861	Curricular, Co-curricular, Social, and Financial Supports for Successful Transfer and Graduation of Engineering Undergraduates from Rural/Nontraditional Backgrounds	S-STEM	University of South Florida
2035556	Rural Electronics Education Hub Pilot in the Upper Mississippi River Basin	ATE	Minnesota State College - Southeast Technical
2037491	Enhancing the Independent Mechatronics Technical Curriculum and Creating a New Pathway from Rural High Schools into Mechatronics Careers	ATE	South Central College
2049681	STEM Graduate Recruitment, Licensure, and Mentorship to Prepare Teachers for Rural Tennessee School Districts	Noyce	University of Tennessee Martin
2050071	Collaborative Research: Investigating STEM Teacher Preparation and Rural Teacher Persistence and Retention	Noyce	University of Wisconsin-River Falls

2050073	Collaborative Research: Investigating STEM Teacher Preparation and Rural Teacher Persistence and Retention	Noyce	Fort Hays State University
2050074	Collaborative Research: Investigating STEM Teacher Preparation and Rural Teacher Persistence and Retention	Noyce	Clarkson University
2050075	Collaborative Research: Investigating STEM Teacher Preparation and Rural Teacher Persistence and Retention	Noyce	University of Kentucky Research Foundation
2050079	Collaborative Research: Investigating STEM Teacher Preparation and Rural Teacher Persistence and Retention	Noyce	University of Alabama at Birmingham
2050080	Collaborative Research: Investigating STEM Teacher Preparation and Rural Teacher Persistence and Retention	Noyce	Texas Tech University
2050095	Collaborative Research: Investigating STEM Teacher Preparation and Rural Teacher Persistence and Retention	Noyce	Morehead State University
2050099	Collaborative Research: Investigating STEM Teacher Preparation and Rural Teacher Persistence and Retention	Noyce	Mississippi State University
2050100	Collaborative Research: Investigating STEM Teacher Preparation and Rural Teacher Persistence and Retention	Noyce	Texas A&M University-Commerce
2050103	Collaborative Research: Investigating STEM Teacher Preparation and Rural Teacher Persistence and Retention	Noyce	Winthrop University
2050107	Collaborative Research: Investigating STEM Teacher Preparation and Rural Teacher Persistence and Retention	Noyce	Alabama A&M University
2050108	Collaborative Research: Investigating STEM Teacher Preparation and Rural Teacher Persistence and Retention	Noyce	Stephen F. Austin State University
2050125	Collaborative Research: Investigating STEM Teacher Preparation and Rural Teacher Persistence and Retention	Noyce	North Dakota State University Fargo
2050249	Collaborative Research: Investigating STEM Teacher Preparation and Rural Teacher Persistence and Retention	Noyce	Texas A&M University
2050336	A Collaborative Regional Alliance to Prepare STEM Secondary Teachers for Service in Rural, High-Need Schools and School Districts	Noyce	University Corporation at Monterey Bay
2050338	Meeting the Demand for Secondary STEM Teachers in Rural and Urban High-need School Districts in Kansas and Missouri	Noyce	Baker University
2050476	Citizen Science: A Pathway to Increase and Diversify the STEM Teaching Force in Rural Georgia	Noyce	Albany State University
2050497	Preparing Highly Effective STEM Teachers for Rural Schools	Noyce	Upper Iowa University
2054966	Appalachian Solutions in Cybersecurity Innovation Initiative: Cybersecurity Technician Pipeline Development in Rural, Eastern Kentucky	ATE	Kentucky Community & Technical College System
2055708	Industry Aligned Rural Engineering Program	ATE	Imperial Valley College
2100012	Increasing the Number and Diversity of Cybersecurity Technicians in Rural North Carolina	ATE	Robeson Community College
2130078	Connecting Science Identity to STEM Success at a Rural Primarily Undergraduate Institution Propelled by an Evidence-Based First Year Experience	S-STEM	Indiana Wesleyan University
2130277	Leveraging Technology: Providing a Comprehensive, Active Learning, Online Support Network for STEM Students Attending a Small, Rural, and Remote Community College	S-STEM	Feather River Community College District
2147890	Developing Computer Science Master Teachers for Georgia Rural Schools	Noyce	Mercer University

2150886	Building Capacity to Expand Recruitment and High-Quality Preparation of Secondary STEM Teachers in High-Need Districts in Rural Virginia	Noyce	Hollins University
2150890	Preparing Rural STEM Teachers for Success	Noyce	Wayne State College
2150926	Gaining Retention and Effectiveness though Advancing Teacher-Centered STEM Professional Learning for STEM Elementary Teachers in Rural Communities	Noyce	Appalachian State University
2151058	Cultivating Exemplary STEM Teachers for High-Need Rural School Districts	Noyce	University of Saint Mary
2151122	Science Teachers for Rural America - A Post-Baccalaureate STEM Teacher Licensure Project	Noyce	Fort Hays State University
2201993	Developing Cybersecurity Technicians through Expanded Pathways in Rural and Underserved Communities	ATE	Lakeshore Technical College
2202077	Engaging Rural Students in Advancement Opportunities through the Field of Data Analytics	ATE	North Arkansas College
2203212	FW-HTF-RL: Collaborative Research: Enabling Marginalized Rural and Urban Digital Workers to Collaborate with AI to Learn Skills, Increase Wages, and Access Creative Work	FW-HTF	Northeastern University
2220586	Supporting Low-Income Students Studying Biology, Chemistry, and Biochemistry from First Year to Graduation in Rural Wisconsin	S-STEM	University of Wisconsin-Stevens Point
2221136	Leveraging Data Science to Promote the Successful Participation of Talented, Low–Income, Undergraduate Students from Rural Alabama in STEM Fields	S-STEM	Jacksonville State University
2221391	Collaborative Planning Grant: Bridging Rural Access in Virginia – Building Partnerships for STEM Pathways	S-STEM	Longwood University
2221538	Increase the STEM Pipeline: Investing to Prepare Talented, Low Income Rural Students for Vital STEM Careers	S-STEM	North Arkansas College
2221637	Partnering with Rural and Low-income Students for Academic Success in the Biological Sciences	S-STEM	North Dakota State University Fargo
2243229	Developing STEM Teachers Across Rural Schools: Using STEM Outreach Programs to Build and Strengthen Identity as STEM Teachers	Noyce	Adams State University
2243323	Building a Pathway for Recruiting and Preparing STEM Teachers in Rural West Central Illinois	Noyce	Western Illinois University
2243334	Equipping STEM Educators to Teach in High Need Rural Schools	Noyce	Dordt University, Incorporated
2243393	Using a Microcredential Model to Prepare Secondary Mathematics and Science Teachers to Meet the Needs of Rural, High-need Districts	Noyce	East Carolina University
2243410	Building Capacity to Address STEM Educator Shortages in Rural South Dakota	Noyce	Black Hills State University
2243433	Energizing STEM Teaching Across Rural Schools	Noyce	Juniata College
2243496	Building Leadership among Science Teachers in Rural Regions: Designing, Developing, and Implementing a Science Teacher Leadership Academy	Noyce	Clemson University
2243541	Building Capacity to Develop STEM Teacher Leaders in Montana Rural and American Indian Schools	Noyce	Montana State University
2300335	Preparing Advanced Manufacturing Technicians for Industry 4.0 in Rural Western Kentucky	ATE	Kentucky Community & Technical College System

2300470	Incorporating Virtual Reality into Advanced Manufacturing Technician Education at a Rural Community College	ATE	Marion Technical College
2300884	Growing Rural Iowa's Cybersecurity Workforce	ATE	Indian Hills Community College
2301188	Recruiting Rural Students and Veteran Populations into an Aviation Maintenance Associate Degree Program	ATE	Kentucky Community & Technical College System
2322514	Accelerating Low-Income College STEM Students to Degree Completion at a Two-Year Hispanic Serving Institution in Rural Central Washington	S-STEM	Yakima Valley Community College
2322614	Onboarding Rural Area Mathematics and Physical Science Scholars	S-STEM	Tennessee Technological University

Appendix D

Active Other EDU Awards Related to Rural STEM Education

Award Number	Title	EDU Division	Program	Organization
1828571	NRT-INFEWS: Preparing future leaders: Rural resource resiliency (R3)	DGE	NSF Research Traineeship (NRT), Project & Program Evaluation	Kansas State University
1946557	CyberCorps SFS Renewal: Strengthening the National Cybersecurity Workforce	DGE	CyberCorps: SFS	Kansas State University
2000865	Broadening Participation in STEM Through Virtual Reality Career Exploration: Introducing Underrepresented Students to High Need STEM Careers	DGE	ECR-EDU Core Research	Rowan University
2142948	CyberCorps Scholarship for Service (Renewal): Preparing Gulf Coast Cyber Scholars	DGE	CyberCorps: SFS	University of South Alabama
2222289	Reimagining Grading to Support Nontraditional and Rural Students in High Enrollment, Gateway STEM Courses	DGE	Postdoctoral Fellowships	North Dakota State University Fargo
2222499	Institute for Measurement Methodology in Rural STEM Education Postdoctoral Research Fellowship (IMMERSE-PRF)	DGE	ECR:BCSER	University of South Carolina at Columbia
1834569	NSF INCLUDES Alliance: Expanding the First2 STEM Success Network	EES	INCLUDES	West Virginia University Research Corporation
1834575	NSF INCLUDES Alliance: Expanding the First2 STEM Success Network	EES	INCLUDES	Fairmont State University
1834586	NSF INCLUDES Alliance: Expanding the First2 STEM Success Network	EES	INCLUDES	Higher Education Policy Commission
1834595	NSF INCLUDES Alliance: Expanding the First2 STEM Success Network	EES	INCLUDES	High Rocks Educational Corporation
1834601	NSF INCLUDES Alliance: Expanding the First2 STEM Success Network	EES	INCLUDES	Associated Universities, Inc.
1912389	Broadening Participation Research Project: Promoting Rural Opportunities for Student Achievement in STEM (PRO-STEM)	EES	HBCU-UP	North Carolina Central University
1953864	TSIP: United Tribes Technical College's Community STEM Engagement Initiative	EES	TCUP	United Tribes Technical College
2116810	HSI Planning Project: Overcoming Barriers in the South Plains: Improving Retention for HSI Community College Students	EES	HSI	South Plains College
2320120	Effective Strategies to Recruit Underserved Students to Baccalaureate Engineering Success and Transition Programs (Recruit-BEST)	EES	ECR:BCSER	West Virginia University Research Corporation

2321159	Rural Veteran Personality, Delay Discounting, and the Interference Preservation Hypothesis	EES	ECR:BCSER	Southern Illinois University at Carbondale

Appendix E

Other Directorates/Offices Awards Related to Rural STEM Education

Award Number	Title	NSF Org	Program	Organization
1852459 2244080	REU Site: Genes & the Environment: Research Experiences for Undergraduates from Rural & Tribal Colleges	BIO	REU	University of North Dakota Main Campus
2341459	BIORETS: Genes & the Environment: Research Experiences for Teachers from Rural & Tribal Sch	BIO	RET, EPSCoR Co-Funding	University of North Dakota Main Campus
1846477	CAREER: Breakthrough Display Technology as a New Medium for Spatial Thinking in STEM	CISE	HCC	Brigham Young University
1917950	Broadening Participation for Remote Communities: Situated Distance Telepresence Mentoring through Embodied Communications	CISE	Cyberlearning	Texas A&M University
1923373	Bringing Computer Science to High Schools in Rural Appalachia	CISE	EWF	Appalachian State University
2026218	Collaborative Research: FW-HTF-RM: Expanding Rural Ceramics Craft and Computational Fabrication: A Synergy	CISE	FW-HTF	University of New Mexico
2026286	Collaborative Research: FW-HTF-RM: Expanding Rural Ceramics Craft and Computational Fabrication: A Synergy	CISE	FW-HTF	University of California-Santa Barbara
2031355	Secure and Upgrade Computer Science in Classrooms through an Ecosystem with Scalability & Sustainability (SUCCESS)	CISE	CSforAll, IIS Special Projects	West Virginia University Research Corporation
2031489	GigCity CS4All: Creating an Inclusive 21st Century Gig-Enabled Teaching and Learning Community	CISE	CSforAll	University of Tennessee Chattanooga
2216625	BPC-DP: Broadening Participation of Underrepresented Groups Through the Computational Core Initiative	CISE	CSGrad4US	Kansas State University
2219333	Building Capacity to Support Elementary CS Pathways Tailored to Rural Needs in Idaho	CISE	CSforAll	American Institutes for Research in the Behavioral Sciences
2219401	Drawing on Kinship: Rurally Sustaining Computational Thinking Pathways	CISE	CSforAll	Digital Promise Global
2219770	Equipping for Praxis: Advancing Computer Science Teachers Through Endorsement	CISE	CSforAll	CodeVA
2318354	K12 CS Pathways for Rural and Tribal Communities	CISE	CSforAll	College of Saint Scholastica
2335751	Education DCL: EAGER: Exploring New Pathways into Cybersecurity Careers for Rural English Learners through XR-enabled Educational Methods	CISE	Secure &Trustworthy Cyberspace	Iowa State University
2339025	CAREER: Leveraging Data Science & Policy to Promote Sustainable Development Via Resource Recovery	CISE	EnvS, EPSCoR Co-Funding	West Virginia University Research Corporation

2401154	K12 CS Pathways for Rural and Tribal Communities	CISE	CSforAll	University of Minnesota-Twin Cities
1916673	Research: Looks Like Me: Leveraging Funds of Identity to Enhance Engineering Career Pursuits in Rural/Reservation Communities	ENG	EngEd	Montana State University
1930777	Research: Practices of Engineers in Rural Schools Involving Students and Teachers (PERSIST) in Engineering	ENG	EngEd	Pennsylvania State Univ University Park
1950597	REU Site: Sustainability of Horizontal Civil Networks in Rural Areas	ENG	EWFD	University of Nebraska-Lincoln
1953601	Sustainable Energy Engineering for Empowering Rural Communities	ENG	RET	East Central University
1953732	Sustainable Energy Engineering for Empowering Rural Communities	ENG	RET	University of Oklahoma Norman Campus
2055138	RET Site: Culturally Responsive Energy Engineering Education in Rural/ Reservation Elementary Schools	ENG	RET	Montana State University
2135080	STEM Excellence in Engineering Equity (SEEE)	ENG	EDA	University of Pittsburgh
2208631	CAREER: Integrating a Data-Driven Approach with Technologies for Sharing Rural Knowledge and Values	ENG	HCC	University of California-Santa Cruz
2217685	BPE-Track 3: Inclusive mentoring hub for enabling pathways from inner-city and rural Appalachian households to engineering in Kentucky and West Virginia	ENG	EDA	University of Kentucky Research Foundation
2219807	Greenway Institute of Elizabethtown College Center for Sustainability and Equity in Engineering	ENG	EDA	Elizabethtown College
2301912	RET Site: Energize Teachers	ENG	RET	Tennessee Technological University
2318489	Design & Development: Colorado Science and Engineering Inquiry Collaborative	ENG	EngEd	University of Colorado at Boulder
2415592	Research: Looks Like Me: Leveraging Funds of Identity to Enhance Engineering Career Pursuits in Rural/Reservation Communities	ENG	EngEd	Purdue University
1834685	Subsistence and Outmigration: Connecting Intergenerational Dialogues between Alaska Native Elders and Youth	GEO	ASSP	University of Arizona
1911558	GEOPATHS-IMPACT: Growing Geoscience Enrolment Through Academic Partnership with NC Community Colleges (GGETAP with NCCC)	GEO	NSF 2026 Fund, IUSE	North Carolina Central University
1940319	CoPe RCN: Resilient Rural Infrastructure	GEO	CoPe	Florida State University
1942460	CAREER: Deciphering the mechanisms of forearc basin formation by engaging undergraduate and middle school students in field and analytical geoscience research	GEO	Tectonics	Montana State University
1950681	REU Site: Research Experience for Community College Students (RECCS) in the Geosciences	GEO	REU	University of Colorado at Boulder

1950702	REU Site: Climate and Atmospheric Science Research Experience in the Center for Climate and Aerosol Research at Portland State University	GEO	Climate & Large-Scale Dynamics, Educational Linkages	Portland State University
2022964	GP-IN: SOARING: Sharing Opportunities, Approaches, and Resources in New Geo-teaching	GEO	Polar Special Initiatives	Kansas State University
2023300	GP-UP: Building a GeoFORCE Learning Community to Attract, Prepare, and Retain Rural, Alaska Native, and First-Generation STEM Majors	GEO	Special Emphasis Program, IUSE	University of Alaska Fairbanks Campus
2113470	GP-IN: Alaska Aquaculture Science Knowledge (ASK)	GEO	Polar Special Initiatives, Special Emphasis Program, IUSE, EPSCoR	Sitka Sound Science Center Inc.
2119992	GP-IN: Getting your feet wet: Advancing geoscience education using water-based field experiences	GEO	Special Emphasis Program, GOLD-GEO	Missouri University of Science and Technology
2230413	GP-IN: Introducing Community College and Pre-College Students to Geoscience through Groundwater Quality Monitoring	GEO	Special Emphasis Program	Kansas State University
2235308	CAREER: Hydrogeologic implications of permafrost thaw - Developing a process-based understanding of biophysical controls and educational tools for rural communities	GEO	Hydrologic Sciences, ANS	Appalachian State University
2325570	GP-IN: Air Across Texas: Scattered and Supported: A program introducing high school students from underrepresented groups to air quality monitoring, research, and careers	GEO	Special Emphasis Program, Educational Linkages	Texas Tech University
1847350	CAREER: An Integrated Research and Education Program in Gravitational-Wave Physics and Astronomy	MPS	LIGO Research Support	Kenyon College
2150226	REU Site: Discrete and Continuous Analysis in Appalachia	MPS	REU, EPSCoR Co-Funding	Fairmont State University
2319428	explOration of Astronomy by Kentucky Students (OAKS)	MPS	PAARE, EPSCoR Co-Funding	University of Louisville Research Foundation Inc.
1849206	RII Track-1: Building on the 2020 Vision: Expanding Research, Education and Innovation in South Dakota	OIA	EPSCoR RII Track-1, EPSCoR Research Infrastructure	South Dakota Board of Regents
2242763	RII Track-1: Building Capacity across Iowa to Meet Human Needs from Things that Grow	OIA	EPSCoR RII Track-1	Iowa State University
2316126	Collaborative Research: RII Track-2 FEC: Where We Live: Local and Place Based Adaptation to Climate Change in Underserved Rural Communities	OIA	EPSCoR RII Track-2 FEC	Regents of the University of Idaho
2316127	Collaborative Research: RII Track-2 FEC: Where We Live: Local and Place Based	OIA	EPSCoR RII Track-2 FEC	Board of Regents, NSHE, obo University of Nevada, Reno

	Adaptation to Climate Change in Underserved Rural Communities			
2316128	Collaborative Research: RII Track-2 FEC: Where We Live: Local and Place Based Adaptation to Climate Change in Underserved Rural Communities	OIA	EPSCoR RII Track-2 FEC	University of South Carolina at Columbia
2316366	Collaborative Research: RII Track-2 FEC: Rural Confluence: Communities and Academic Partners Uniting to Drive Discovery and Build Capacity for Climate Resilience	OIA	EPSCoR RII Track-2 FEC	Oklahoma State University
2316367	Collaborative Research: RII Track-2 FEC: Rural Confluence: Communities and Academic Partners Uniting to Drive Discovery and Build Capacity for Climate Resilience	OIA	EPSCoR RII Track-2 FEC	Louisiana State University
2316368	Collaborative Research: RII Track-2 FEC: Rural Confluence: Communities and Academic Partners Uniting to Drive Discovery and Build Capacity for Climate Resilience	OIA	EPSCoR RII Track-2 FEC	University of Nebraska-Lincoln
1735753	Type I: I-Corp Site: Idea 2 Impact GO (I2I GO) - Driving the Innovation Ecosystem at East Carolina University to Build New Enterprises for the Benefit of Rural Eastern NC	TIP	I-Corps-Sites	East Carolina University
2229654	POSE: Phase I: OPERA: An Open-Source Ecosystem for Broadband Prairie	TIP	POSE	Iowa State University

CEOSE MEMBERSHIP

***Current Member**

****Term began in 2024**

Dr. John M. M. Anderson*
Dean
College of Engineering and Architecture
Howard University
Washington, DC 20059

Dr. Gilda A. Barabino*
President and Professor
Olin College of Engineering
Needham, MA 02492

Dr. Suzanne Barbour*
Dean of the Graduate School
Vice Provost for Graduate Education
The Graduate School
Duke University
Durham, NC 27708

Dr. Sean Chandler**
President
Aaniiih Nakoda College
Harlem, MT 59526

Dr. Tabbetha Dobbins*
Vice President for Research
Dean of the Graduate School Division of University Research
Department of Physics & Astronomy
Rowan University
Glassboro, NJ 08028

Dr. Kaye Husbands Fealing, Former Chair
Dean of Ivan Allen College of Liberal Arts - Ivan Allen Jr. Chair
Georgia Institute of Technology
Atlanta, GA 30332

Dr. Jose D. Fuentes, Former Chair
Professor of Meteorology
Department of Meteorology Pennsylvania State University
State College, PA 16801

Dr. Ann Quiroz Gates*
Senior Vice Provost Faculty Affairs
Director CASHI INCLUDES Alliance
The University of Texas at El Paso
El Paso, TX 79968

Dr. Sandra Graham*
Distinguished Professor and Presidential Chair in Education and Diversity
Department of Education
University of California - Los Angeles
Los Angeles, CA 90095

Dr. Peter Hauser**
Center for Culture and Language
National Technical Institute for the Deaf
Rochester Institute of Technology
Rochester, NY 14623

Dr. Rupa Iyer**
Vice President of Research Innovation, and Economic Development
Tarleton State University
Stephensville, TX 76402

Dr. Okhee Lee**
Department of Teaching and Learning
Steinhardt School of Culture, Education and Human Development
New York University
New York, NY 10003

Dr. Cynthia Lindquist*
President
Cankdeska Cikana Community College Spirit Lake Dakota
Fort Totten, ND 58335

Dr. James R. Martin II*
Vice Chancellor for STEM Research and Innovation
Swanson School of Engineering
University of Pittsburgh
Pittsburgh, PA 15261

Dr. Vernon Morris*
Professor of Chemistry and Environmental Sciences
Director of the School of Mathematical and Natural Sciences Arizona State University
Phoenix, AZ 85306

Dr. Timothy Pinkston*
George Pfleger Chaired Professor of
Electrical and Computer Engineering Vice
Dean for Faculty Affairs
USC Viterbi School of Engineering
University of Southern California
Los Angeles, CA 90089

Dr. Susan Renoe*
Associate Vice Chancellor
Division of Research, Innovation and Impact
Assistant Professor
School of Journalism
University of Missouri
Columbia, MO 65211

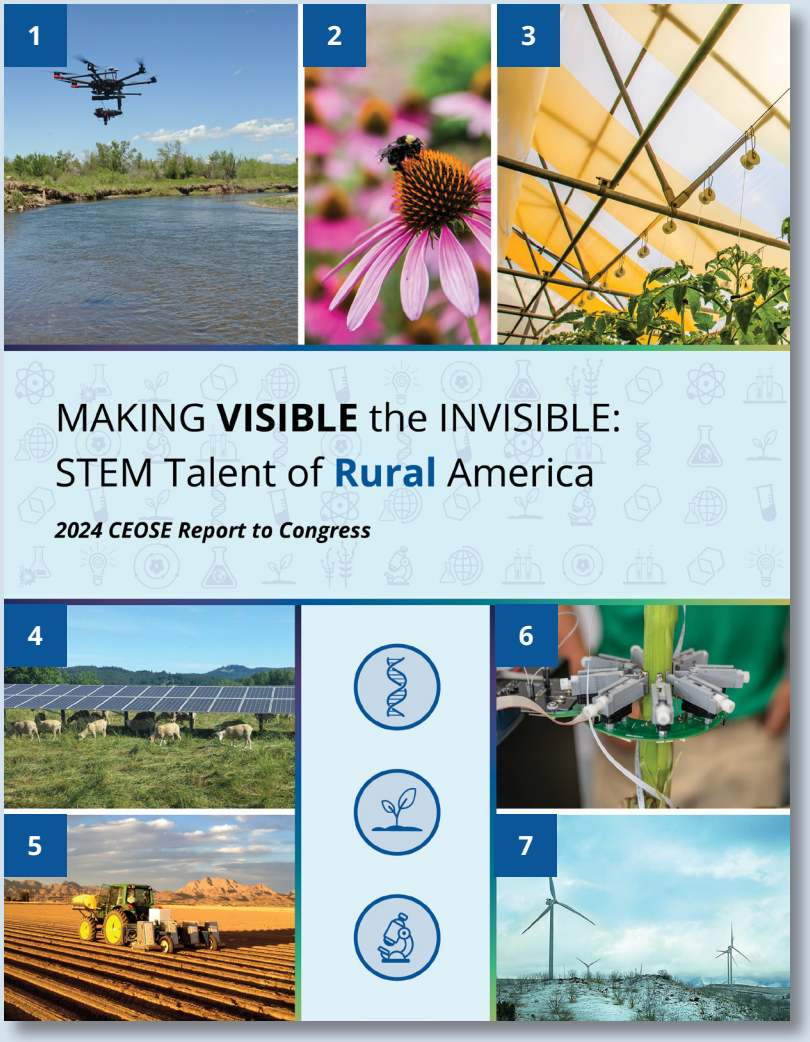
Dr. Manuel Rodriguez Martinez**
Department of Computer Science and Engineering
College of Engineering
University of Puerto Rico- Mayaguez
Mayaguez, PR 00681

Dr. Barbara E. Walker*
Director, Strategic Research Initiatives
Special Assistant to the Executive Vice Chancellor
for Diversity Initiatives
UC Santa Barbara
Santa Barbara, CA 93106

Dr. David K. Wilson*
President
Morgan State University
Baltimore, MD 21251

IMAGE CREDITS MAP

Front Cover



Front Cover Images by Number

1 **Front Cover Image 1**
Credit: Image Credit: Joe Shaw, Montana State University

2 **Front Cover Image 2**
Credit: Mark Stone/ University of Washington Photography

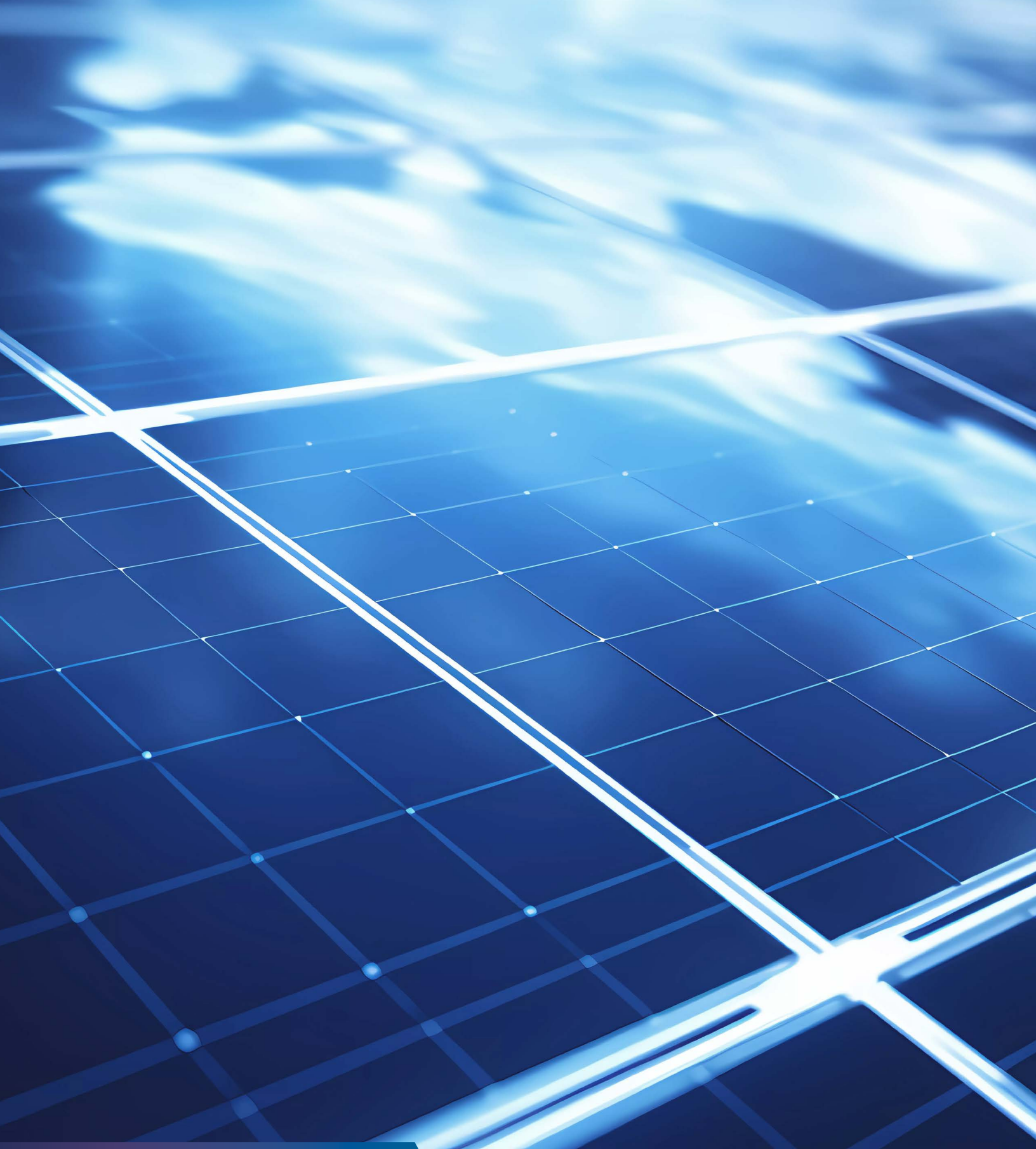
3 **Front Cover Image 3**
Credit: UbiQD

4 **Front Cover Image 4**
Credit: Mark Floyd, Oregon State University

5 **Front Cover Image 5**
Credit: ©Blue River Technology

6 **Front Cover Image 6**
Credit: AI Institute for Resilient Agriculture

7 **Front Cover Image 7**
Credit: Rick Schumaker, Idaho EPSCoR



2024 CEOSE Report to Congress

U.S. National Science Foundation

www.nsf.gov