



PennState

20
22

Annual Report of Research Activity

OFFICE OF THE SENIOR VICE PRESIDENT FOR RESEARCH

Impact

Penn State is driving research with global impact, bringing innovation, collaboration, and translation to the worldwide stage. In 2022, we set another record for research expenditures, advancing new research directions and developing innovations aligned with the United Nations' sustainability goals. These are just a few ways that Penn State research achieves global, national, and local impact—changing lives and communities as we fulfill our mission as a land-grant university.

Our research at Penn State is dedicated to the “long game,” with diversified programs that impact multiple levels across society. A research program at Penn State doesn't end with scientific results in a lab or a publication, but contributes in several areas, resulting in scientific, educational, humanitarian, economic, health, and community benefits over many years to come. This is the core of research in service to society—a role we take seriously.

Our record-breaking total research expenditures (**\$1.034B in fiscal year 2021-2022**) are just one indicator of how Penn State research drives progress. The discoveries, knowledge generation, applications, and implementations engendered by our research inject optimism about the fate of humankind. At the onset of the pandemic in April 2020, I received a card from two children that read, “Thank you for helping people get better by doing science experiments.” This is the faith and confidence our communities have in our research and our researchers.



A handwritten signature in blue ink that reads "Lora G. Weiss".

LORA G. WEISS
Senior Vice President
for Research

Our scientific and scholarly leaders continue to produce top-notch results in areas including materials engineering, critical minerals, nanofabrication, cancer research, biology, arts, architecture, analytics and machine learning, health and wellness, clinical trials, social sciences, energy and the environment, national security, and more. Our research often ranks in the **Top 25** nationally in expenditures, with **12 programs ranked in the top 10**. The unparalleled interdisciplinary structure and cohesive nature of our enterprise allow us to reach into communities across our commonwealth, collectively leveraging our 24 campuses to drive progress across the state.

Spearheaded by President Neeli Bendapudi, Penn State is on an exceptional research trajectory, focused on bettering the lives of our students, our communities, our commonwealth, and our planet. As Senior Vice President for Research, my vision is to drive a research portfolio that tackles the most difficult global challenges while shepherding the growth of students, exciting them about research developments, advancing diversity in research, and ensuring sustainability—all while focusing on the long game of meaningful impact.

I am proud to represent research at Penn State, and I look forward to 2023 and the positive impacts we will make in many areas, locally and around the world. Thank you for your passionate dedication to the advancement of scholarly and scientific research and to driving our Penn State research enterprise to new heights.

The Long Game.

Penn State research has provided countless innovations and an abundance of scholarly work to benefit science, healthcare, our communities and our planet. The breadth and depth of our scientific expertise has made lasting impacts across our commonwealth, our nation and our world. The following pages present a few highlights of 2022 from the contributions of our interdisciplinary institutes, as well as our Applied Research Lab. Cumulatively, these highlights represent just a snapshot of the immense power and long-term contributions of the research enterprise at Penn State.

STUDENT ENRICHMENT & WORKFORCE DEVELOPMENT

Penn State has long been committed to involving undergraduates in research. The University graduated over 6,500 students in STEM fields in 2022, bringing more students into science and engineering than any other U.S. university. Our partnerships with industry provide world-class environments for workforce development, with exposure to technologies such as fermentation in our CSL-Behring partnered commercially available facility.

Research Goals:

- ADVANCING PRECISION HEALTH IN CONTEXT
- STEWARDING OUR PLANET'S RESOURCES
- TRANSFORMING EDUCATION AND ENHANCING ACCESS
- EMPOWERING SCIENCE AND SOCIETY THROUGH DIGITAL INNOVATION
- ADVANCING THE ARTS AND HUMANITIES
- INVIGORATING ENTREPRENEURSHIP, TECHNOLOGY TRANSFER, AND ECONOMIC DEVELOPMENT
- INNOVATION FOR NATIONAL SECURITY ASYMMETRY
- MAINTAINING AND NURTURING AN EXCEPTIONAL WORKFORCE

OUR RESEARCH IS GROUNDED IN OUR STRATEGIC GOALS, REPRESENTING A WIDE RANGE OF PRIORITIES ACROSS THE ENTERPRISE. OUR LONG-TERM CONTRIBUTIONS ACROSS SCIENTIFIC, ECONOMIC, SOCIAL, HEALTH, POLICY, AND HUMANITARIAN REALMS CONTINUE TO POSITIVELY IMPACT OUR WORLD.



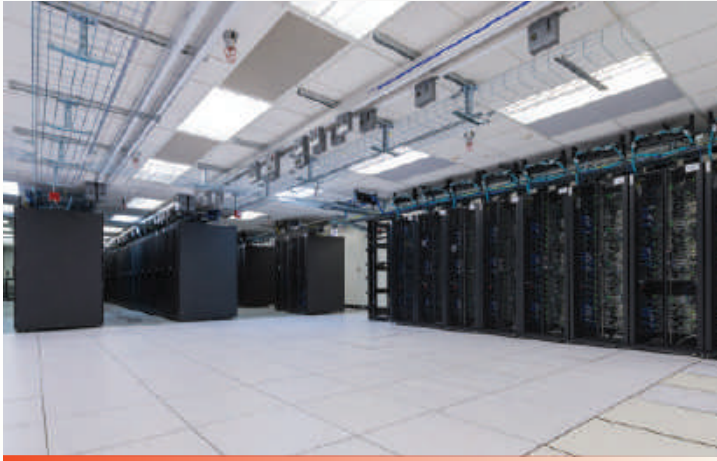
CANCER INSTITUTE

Penn State Cancer Institute strives to reduce the burden of cancer in central Pennsylvania and beyond through compassionate cancer care, education, and collaborative research to understand the origins of cancer, identify and overcome barriers to care, and develop and test next generation therapeutics. Research by Cancer Institute members Deborah Kelly and Susan Hafenstein recently resulted in the first atomic imaging and structural studies on breast cancer susceptibility proteins. Work by the Kelly and Hafenstein groups has also provided new molecular insights for human papilloma virus (HPV) and the tumor suppressor TP53. The discovery of these new structures provides new approaches for restoring the function of mutated proteins in cancer cells, along with the ability to map HPV and TP53 variants in cancer cells. These projects may develop improved therapeutics and vaccine designs as well as novel clinical strategies for cancer prevention involving mutations in the tumor suppressor genes BRCA or TP53.



CLINICAL AND TRANSLATIONAL SCIENCE INSTITUTE

The Clinical and Translational Science Institute vision is to serve as the cornerstone of clinical and translational science at Penn State, meaning we aim to speed the adoption of best practices into community settings. Ours is one of few CTSIs in the nation situated in a rural catchment area, and we work hard to advance research in rural communities. In 2022, we put out special calls for funding through our pilot funding and Bridges to Translation funding, for projects with a rural focus. We are also expanding the future pipeline of rural researchers: Seven of eight awardees of this cycle's KL2, an NIH-funded research training program for junior faculty, have a rural focus for their research. Further, we are excited to collaborate with Primary Health Network (PHN) and Allegheny Health Network (AHN). Built into our renewal awarded in 2021 are several opportunities to grow these partnerships. This fall, we received 18 applications to a collaborative PSU/AHN funding announcement and awarded seven, with a goal to bridge partnerships and promote population health.



INSTITUTE FOR COMPUTATIONAL AND DATA SCIENCES

“Roar Collab,” the Institute of Computational and Data Sciences’ newest high-performance research computing cluster, is helping researchers across disciplines and across the Penn State system collaborate on projects aimed at solving some of science and society’s biggest problems. From exploring the depths of outer space to crunching numbers for genome analysis, researchers rely on the Roar Collab environment to provide the necessary computational power to undertake investigations that would be either impossible or prohibitively time-consuming with laptops and other conventional computers. The cluster’s design also allows for frequent software updates and hardware upgrades to keep pace with the ever-changing requirements and growing needs of Penn State’s scientific community. As the user base continues to grow rapidly, Roar Collab will become the flagship cluster for Penn State research.



INSTITUTES OF ENERGY AND THE ENVIRONMENT

The Institutes of Energy and the Environment address science-based solutions through interdisciplinary research that improves our society and planet. Our researchers work with government and industry on technology, law, and policy to solve some of the world’s most challenging energy and environmental issues, with climate and risk continuing to be areas of focus in 2022. Penn State is regularly recognized in these areas by the U.S. Department of Energy and other funding agencies, as our researchers and centers are frequently tapped for their knowledge and expertise. Additionally, with an excellent foundation in agriculture and biology, Penn State continues to capitalize on researcher strengths in the areas of biofuels and renewable energy solutions. Penn State has also been a recognized leader in air quality and health due to the University’s extraordinary capabilities to measure and monitor air quality as well as its commitment to supporting communities through health and justice. Finally, from health to the ecosystem to energy, Penn State researchers continue to build strong projects focused on water and related research areas, to bring solutions to the world’s most essential resource.



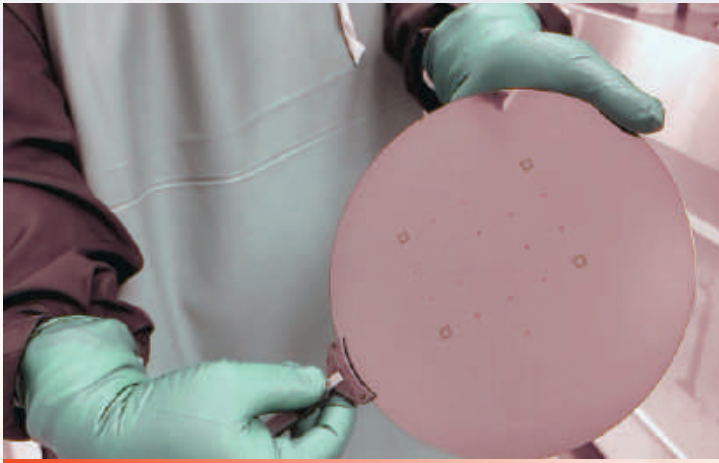
HUCK INSTITUTES OF THE LIFE SCIENCES

In 2022, the Huck Institutes made a special effort to support and celebrate Penn State researchers pursuing high-risk, high-reward lines of inquiry that push past the boundaries of conventional science. When several proposals were deemed too risky for NSF or NIH support, Huck distributed seed grants to foster highly novel work across a wide range of disciplines at Penn State. Huck pioneers have used machine learning to help end a locust plague, public “junk” data to track the spread of viruses, Neanderthal DNA to understand the contemporary human biome, and weather surveillance technology to address infant mortality rates. Huck’s world-renowned faculty and scientists are devising novel methods for diagnosing breast cancer, bolstering crop resiliency, and engineering universal donor stem cells—taking risks and changing the landscape of science. This is all possible because of Huck’s aggressive approach to bringing breakthrough solutions to the world’s biggest health crises, leveraging the interdisciplinary ecosystem within Penn State’s research enterprise.



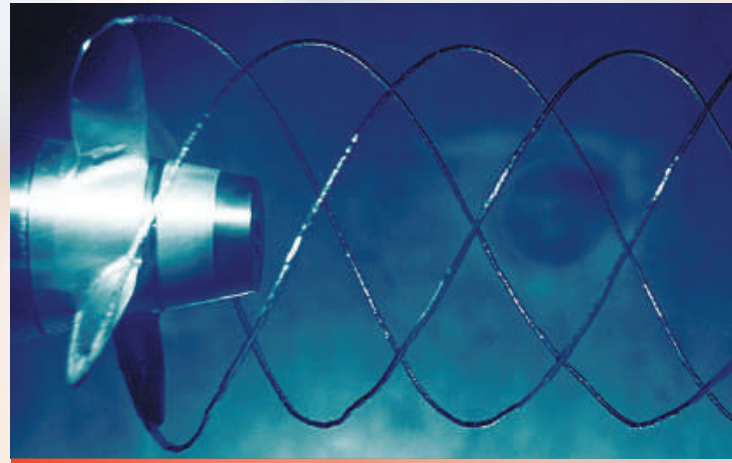
SOCIAL SCIENCE RESEARCH INSTITUTE

The Social Science Research Institute’s Clearinghouse for Military Family Readiness is an applied research center committed to advancing the health and well-being of service members, veterans, and their families. The Penn State Veterans Engaging in Transition Studies (VETS) Survey is independently administered by researchers at the Clearinghouse to examine the impact of emergent societal influences on the transition back to civilian life; identify the successes and challenges of veterans five years post-transition; assess well-being outcomes during the COVID-19 pandemic; and evaluate the overall efficacy of program use. Data collected by these initiatives has been used to provide empirical justification for the National Veterans Policy Framework and to inform a policy response to military sexual trauma (MST). The data have also provided empirical evidence for the effects of combat, moral injury, adverse childhood experiences and MST on veterans’ well-being, evidence that is being used to develop online screening and other tools for policymakers and health professionals.



MATERIALS RESEARCH INSTITUTE

The Materials Research Institute (MRI) focuses on interdisciplinary materials research with profound societal impacts. Penn State ranks first in the nation for materials science and second in materials engineering, as per 2021 National Science Foundation research expenditure rankings. Of particular interest are our core facilities, the Materials Characterization Laboratory and the Nanofabrication Laboratory, which enable high-quality, cost-effective research serving the needs of our federal sponsors and industrial partners. These facilities support both research awards and service level activities and generate new materials that improve society across all economic sectors. MRI's infrastructure provides resources for more than 350 tenured faculty across 8 colleges and more than 30 departments. In addition, MRI partners with more than 100 companies and 250 independent organizations. One example of MRI's collaborative approach, related to the newly passed CHIPS and Science Act, is an effort to leverage institute resources and partnerships to develop a regional mid-Atlantic hub for semiconductor research, manufacturing, and workforce development.

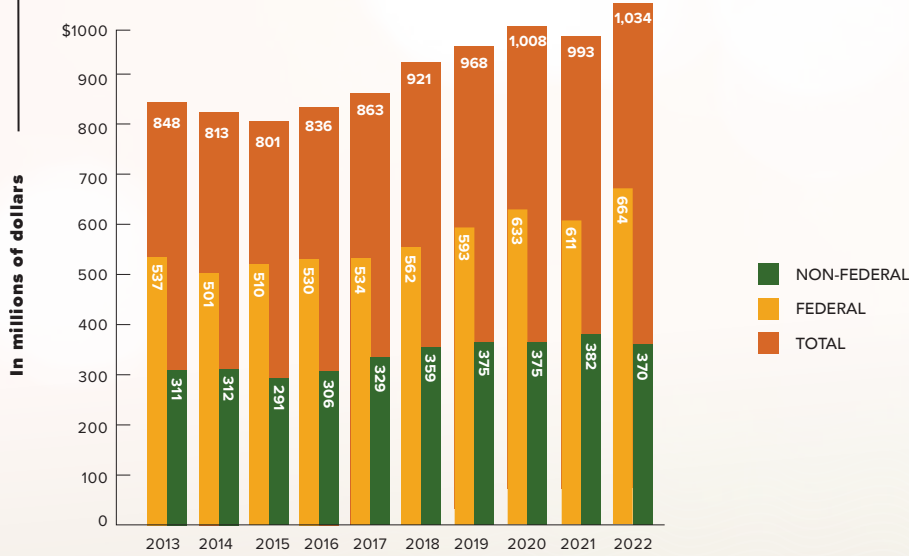


APPLIED RESEARCH LABORATORY

The Applied Research Laboratory (ARL) was established at Penn State in 1945 at the request of the U.S. Navy. While the Laboratory originally focused its research on undersea technologies, today more than half of our ARL's portfolio enables capabilities above the ocean's surface. ARL also serves as an integral part of Penn State's educational mission by advising students, teaching classes, and collaborating with faculty to advance the University's larger academic goals. In 2022, ARL's research teams executed more than \$275 million in basic scientific exploration, proof of principal/proof of concept experimentation, applied research and development, rapid prototyping, and operational support for a sponsor base spanning all military services, much of the extended U.S. national security community, and other government agencies. In addition, in 2022 ARL began a \$34.3 million dollar renovation to the Garfield Thomas Water Tunnel. The project will address accessibility, code compliance and safety concerns while improving the overall functionality for the facility.

TOTAL RESEARCH EXPENDITURES, 2013-2022

(Federal and Nonfederal)

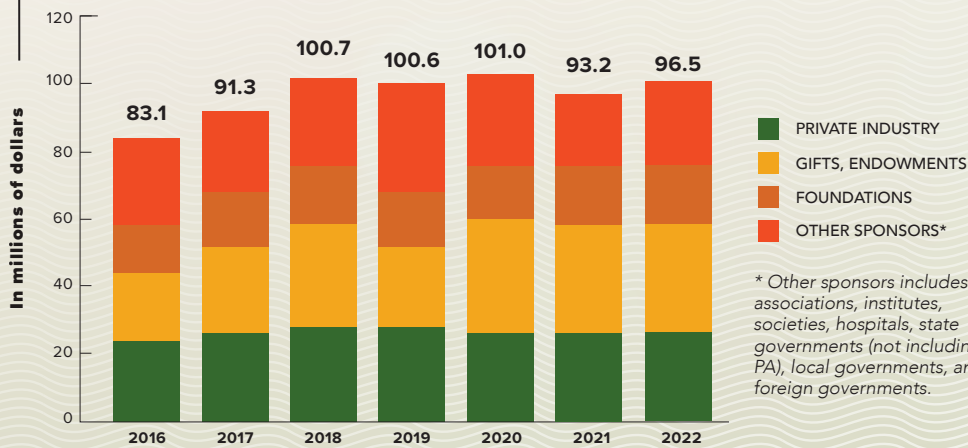


SOURCES OF RESEARCH FUNDING

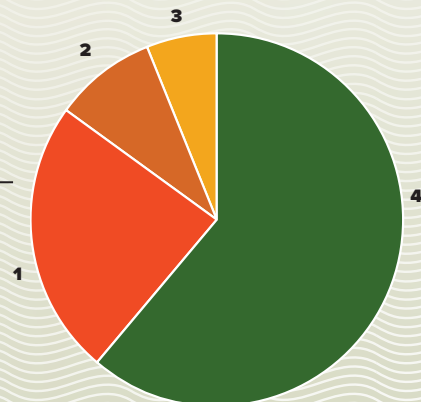
- 1 Federal **\$663,700,000**
 - 2 University **\$223,120,000**
 - 3 Industry and other **\$96,502,000**
 - 4 Commonwealth of Pennsylvania **\$50,919,000**
- TOTAL \$1,034,241,000**

INDUSTRY, FOUNDATIONS, AND OTHER SPONSORS

(excluding Federal, Federal flow-through, Commonwealth of PA, and internal PSU funds)

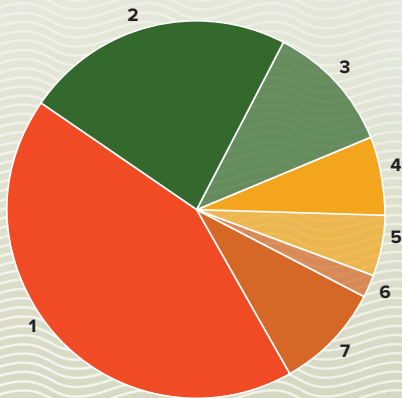


* Other sponsors includes associations, institutes, societies, hospitals, state governments (not including PA), local governments, and foreign governments.



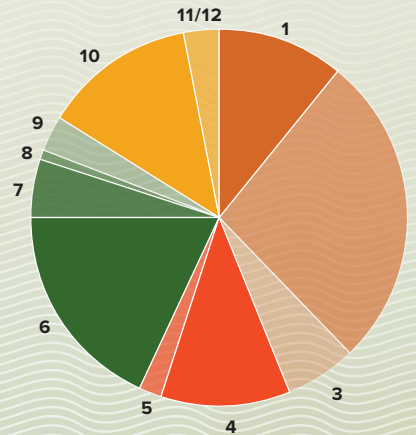
EXPENDITURES FROM FEDERAL AGENCIES

1 Department of Defense \$272,714,000
2 Department of Health and Human Services \$165,225,000
3 National Science Foundation \$74,488,000
4 DOE \$39,548,000
5 USDA \$33,976,000
6 NASA \$17,846,000
7 Other \$59,903,000
Transportation \$8,982,000
Education \$3,593,000
Commerce \$3,377,000
Interior \$2,100,000
Other Federal \$41,851,000
TOTAL \$663,700,000



EXPENDITURES BY PERFORMING UNIT

1 Agricultural Sciences \$114,307,000
2 Defense Related Research Units \$276,625,000
3 Earth and Mineral Sciences \$68,369,000
4 Eberly College of Science \$109,669,000
5 Education \$18,790,000
6 Engineering \$180,976,000
7 Health and Human Development \$46,674,000
8 Information Sciences and Technology \$11,893,000
9 Liberal Arts \$33,232,000
10 Medicine \$146,375,000



11 Other Campuses \$15,735,000
Altoona College \$1,447,000
Berks College \$646,000
Capital College \$3,437,000
Great Valley \$428,000
Penn State Erie, The Behrend College \$7,346,000
Other Commonwealth Campuses \$2,431,000
12 Other Colleges \$11,596,000
Arts and Architecture \$1,915,000
Communications \$781,000
International Affairs \$551,000
Law School \$1,356,000
Nursing \$3,476,000
Smeal College of Business \$3,517,000
TOTAL \$1,034,241,000

PENN STATE TECHNOLOGY TRANSFER AT A GLANCE

Total revenue: \$5.5 million

204
INVENTION
DISCLOSURES
RECEIVED

47
U.S. PATENTS
ISSUED

3
START-UP
COMPANIES
FORMED

15
LICENSES
AND OPTIONS
EXECUTED

Technology transfer data are for the period January–December 2021.

A SAMPLING OF MAJOR AWARDS

COVID AND PREGNANCY

A \$3.9 million grant from the Pennsylvania Department of Health will support a Penn State-led project examining the impact of COVID-19 on pregnancy. The researchers will conduct a multi-site study to examine the health outcomes for pregnant women and their infants before and after childbirth.

MUSHROOM FARMING

A nearly \$4 million grant from the United States Department of Agriculture will support an interdisciplinary, multi-university team of researchers as they investigate technologies designed to address labor shortages on mushroom farms.

FEED THE FUTURE

A grant of up to \$39 million over five years by the U.S. Agency for International Development will establish the Feed the Future Innovation Lab for Current and Emerging Threats to Crops at Penn State.

LANGUAGE TECHNOLOGY

A nearly \$3 million grant from the National Science Foundation will fund a five-year Penn State graduate training program to address key usability challenges in human technologies used for accessing governmental, community, health, and educational services.

RISK RESPONSE

A multi-institutional research team led by Penn State has been awarded a \$17 million, five-year grant from the U.S. Department of Energy to understand how interconnected systems are exposed to natural hazards to create societal risks and how societies respond and adapt to these risks.

EVIDENCE-BASED POLICY

The Penn State Evidence-to-Impact Collaborative has been awarded an infrastructure grant of over \$1.4 million from the Pew Charitable Trust to support the transition and development of state-of-the-art tools to accelerate evidence-informed policymaking.

SUMMARY OF RESEARCH PROPOSALS AND AWARDS

\$2.98_B

**TOTAL
AMOUNT OF PROPOSALS
SUBMITTED**

\$851_M

**TOTAL
AMOUNT OF
AWARDS**

4,873

**PROPOSALS
SUBMITTED**

3,794

**AWARDS
RECEIVED**

2,340

**NEW & COMPETING
CONTINUATION AWARDS
RECEIVED**

2,538

**INVESTIGATORS
RECEIVING
AWARDS**

1,161

SPONSORS

**FOR MORE INFORMATION,
VISIT OUR WEBSITE:**

research.psu.edu

research.psu.edu

**FOR THE LATEST NEWS ABOUT
PENN STATE RESEARCH, VISIT:**

news.psu.edu/topic/research

IMAGE CREDITS:

Cover: Katy Gerace/Penn State. See also below.

Page 4: Cancer Institute: Penn State Health

Page 4: CTSI: Penn State Health

Page 5: ICDS: Penn State

Page 5: IEE: Penn State Greater Allegheny

Page 6: Huck: Huck Institutes/Penn State

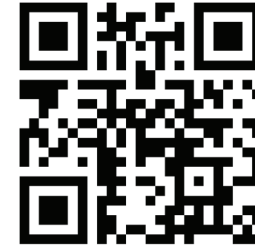
Page 6: SSRI: iStock

Page 7: MRI: Seana Wood/ Materials Research Institute/Penn State

Page 7: ARL: Applied Research Laboratory/Penn State

ABOUT THE COVER:

This colorized electron image of glass ceramics by graduate student Katy Gerace, reminiscent of blossoming sunflowers, captures a silica-based glass matrix with lithium niobate and potassium niobium silicate oxide crystalline phases. Gerace's image was awarded Best of Show in the Department of Materials Science and Engineering Materials Visualization Competition in 2021.



FOLLOW US ON LINKEDIN:

[linkedin.com/company/penn-state-research/](https://www.linkedin.com/company/penn-state-research/)



This publication is available in alternative media upon request. Penn State is committed to affirmative action, equal opportunity, and the diversity of its workforce. This report was produced by University Marketing. U.Ed. RES 23-107