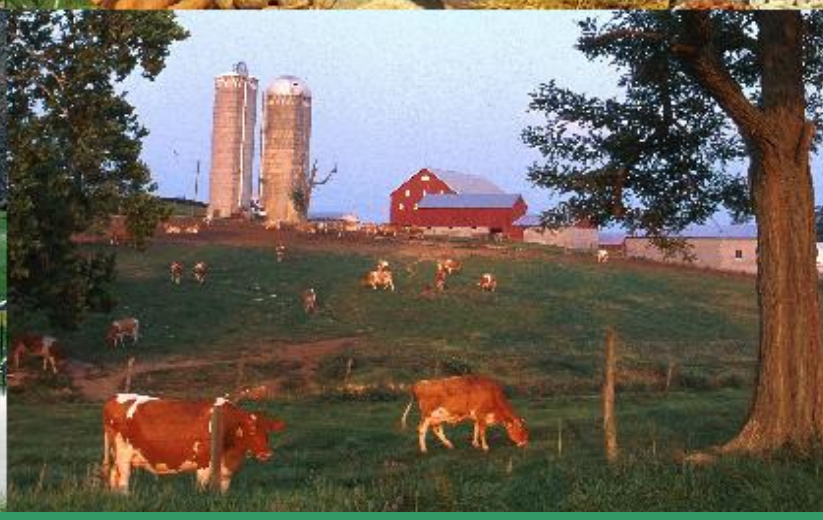
A Report by the
NATIONAL ACADEMY OF PUBLIC ADMINISTRATION
For the Agricultural Research Service

Agricultural Research Service
Office of National Programs Revitalization



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June 2020

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NATIONAL ACADEMY OF PUBLIC ADMINISTRATION

June 2020

Agricultural Research Service: Office of National Programs Revitalization

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The views expressed in this report are those of the study team. They do not necessarily reflect the views of the Academy as an institution.

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Foreword

Created in 1953, the Agricultural Research Service (ARS) is widely recognized as the leading agricultural research organization in the world. Since its creation, ARS' approach to conducting and managing its research efforts has continuously evolved to meet new challenges and opportunities in plant and animal research. Today, ARS' Office of National Programs organizes and oversees about 690 research projects at 90 locations across the United States, its territories, and abroad.

ARS contracted with the National Academy of Public Administration (the Academy) to perform an independent assessment of its national program structure and research and development management processes. This assessment, performed by a study team with support and guidance from an Expert Advisory Group of Academy Fellows, recommends ways that ARS can enhance its innovative, impactful research and take greater advantage of potential synergies across the Agency's many program areas.

As a congressionally chartered, independent, non-partisan, and non-profit organization with over 900 distinguished Fellows, the Academy has a unique ability to bring nationally-recognized public administration experts together to help government agencies address challenges. We greatly value the constructive engagement of ARS employees as well as many other individuals who provided important observations and context to inform this report.
I am deeply appreciative of the work of three Academy Fellows who served on this Expert Advisory Group. I also commend the Academy study team that researched, analyzed, and contributed valuable insights and expertise throughout the project.

Given both the importance and complexity of its work, I trust that this report will be useful to ARS as it considers how to shape and implement changes that can further advance this vital agricultural research mission.

Teresa W. Gerton
President and Chief Executive Officer
National Academy of Public Administration

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Acronyms and Abbreviations

Acronym or Abbreviation	Definition
AgCROS	Agricultural Collaborative Research Outcomes Systems
AI	Artificial Intelligence
APHIS	Animal and Plant Health Inspection Service
ARS	Agricultural Research Service
Academy	National Academy of Public Administration
BIP	Breeding Insight Platform
BMGF	Bill & Melinda Gates Foundation
BoSC	Board of Scientific Counselors
CGIAR	Consortium of International Agricultural Research Centers
CRIS	Current Research Information System
DA	Deputy Administrator
DARPA	Defense Advanced Research Projects Agency
DOI	Department of the Interior
EAG	Expert Advisory Group
EMBRAPA	Brazilian Agricultural Research Corporation
EPA	Environmental Protection Agency
FACA	Federal Advisory Committee Act
FSIS	Food Safety and Inspection Service
FTE	Full-Time Equivalent
FWS	U.S. Fish and Wildlife Service
GIS	Geographic Information System
HR/HR	High-Risk, High-Return
INRAE	National Institute for Agriculture, Food, and Environment

NAL	National Agricultural Laboratory
NASA	National Aeronautics and Space Administration
NIFA	National Institute of Food and Agriculture
NIH	National Institutes of Health
NOAA	National Oceanic and Atmospheric Administration
NP	National Program
NPA	National Program Area
NPL	National Program Leader
NRC	National Research Council
NRCS	Natural Resources Conservation Service
OMB	Office of Management and Budget
ONP	Office of National Programs
ORD	Office of Research and Development
ORIP	Office of Research Infrastructure Programs
OSC	Office of Strategic Coordination
OTT	Office of Technology Transfer
PDI	Partnerships for Data Innovations
R&D	Research and Development
REE	Research, Education, and Economics
RFP	Request for Proposals
SCINet	Scientific Computing Initiative
UAS	Unmanned Aerial Systems
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USWBSI	United States Wheat and Barley Scab Initiative

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Executive Summary

For decades, the Agricultural Research Service (ARS) has been deemed a world leader in plant and animal research. With a broad national network of research locations, and around 2,000 scientists, the Agency has about 690 on-going research projects. Its work has enormous impact not only in the United States, but all over the world.

ARS contracted with the National Academy of Public Administration (the Academy) to conduct an independent assessment during nine months of its national program structure and research and development (R&D) management processes. Impetus for this work stems from a recognition that its approach to managing its R&D work has not been extensively reviewed for almost two decades. Given the rapid and profound changes in agricultural science and use of technology to enhance research, ARS leaders determined it best to refresh its approach and identify areas to improve the impact of its vital work.

The overall aim of this report is to enable ARS to institutionalize a culture more conducive to cross-cutting and innovative, riskier research in order to achieve greater mission impact. The recommendations presented in this report should not be considered as standalone initiatives, but rather as part of an integrated strategy aimed at strengthening a culture of innovative research over time. Success will require sustained leadership with a focus on continuous improvement supported by a clear and consistent message.

This assessment generally finds that ARS approaches its enormous research portfolio with great care, with a goal to ensure high impact results and sound use of appropriated funds. This report does not propose what might be called fundamental changes that suggest extensive re-organization of the enterprise is needed. Rather, this report provides findings and recommendations that build on the existing organizational infrastructure in a manner that facilitates more innovative, riskier research, with an aim to also take fuller advantage of potential synergies across the Agency's program areas.

The Academy appointed an Expert Advisory Group of three Academy Fellows to oversee a professional study team while conducting the review.

Over several decades, ARS' funding model, organizational structure, and program cycle have enabled it to sustain its problem-focused approach to R&D for thousands of customers and stakeholders. Key enablers of ARS' success include:

- Stable funding that allows ARS scientists to formulate and conduct research with, at a minimum, 5-year time horizons;
- Geographically-distributed organization and funding linked to the particular needs of local agricultural stakeholders;
- Research organized under National Programs enabling domain-specific focus.

The characteristics of the ARS model have always presented challenges as well as advantages. These challenges have been exacerbated by significant changes in the research

environment in recent years. In response to its changing research environment, ARS has undertaken a number of innovative R&D management initiatives.

This report contains seventeen recommendations, organized into three categories, that target opportunities to improve ARS' mission impact. These three categories are:

1. Developing and communicating an overall strategy for R&D management initiatives;
2. Optimizing the organization to promote more innovative research and build enterprise-level research capabilities; and
3. Building support for enterprise-level, strategic research investments.

The report's eighteen recommendations are organized under seven findings from the assessment of the ARS research organization. The recommendations are numbered consistent with the chapters in which they appear, thus Recommendation 3.1 is the first recommendation discussed in Chapter 3.

Finding 1. There is a need to develop and communicate an overall R&D management strategy.

In response to changes in its research environment, ARS leaders have experimented with a variety of innovative R&D management initiatives. While each of these initiatives is promising, the study team identifies three key success factors on which ARS should improve. First, ARS should clarify how the initiatives fit together with each other in a broader R&D management strategy to achieve impact. Second, ARS should improve communication of these initiatives. Finally, ARS should ensure a balanced portfolio of research, giving attention not only to high-risk/high-return research, but also to lower-risk, but potentially high-impact research.

Recommendation 3.1: *Develop a strategy that clearly communicates to the entire organization the objectives of its various R&D management initiatives and how they fit together as part of an overall enterprise strategy for achieving greater mission impact.* The strategy should do the following things:

- Group the initiatives;
- Clarify the objectives for each initiative;
- Identify connections between initiatives and normal NP research; and
- Communicate how the portfolio of initiatives fits into the organization's broader goals and efforts.

Recommendation 3.2: *The R&D management strategy should include a balanced portfolio for achieving impact with a focus on high-risk/high-return research.*

- **Impact should be the overarching goal.** All research in the portfolio does not need to be high risk to be high impact. There are different means of getting to high impact. One aspect of strategy should be taking benefits of high risk research, such as new tools, and making them available for enabling more efficient research throughout the ARS enterprise (e.g. Breeding Insight).
- **Focus on impact should be combined with a balanced portfolio approach.** ARS should clearly prioritize initiatives according to their potential impact, invest in these initiatives based on the impact-based prioritization, and then communicate the priority and investment plan to the entire organization. A standard consideration in this balanced portfolio approach would be to ensure a healthy mix of risks.

Finding 2. There are opportunities at ARS to mitigate insularity within the intramural research organization.

Insularity is one general impediment to innovative research, and is of particular concern for an intramural research organization like ARS. Good practice research suggests mitigating insularity at three levels of the ARS research enterprise: 1) the NPL level; 2) the NP plan level; and 3) between domestic and international organizations.

Recommendation 3.3: *Adopt a system of regular rotation for National Program Leads that includes a mix of external and internal personnel.*

Recommendation 3.4*: Institute a regular process for prospective external expert review of its National Program 5-year plans that focuses on identifying potential synergies across National Programs, especially National Programs in different National Program Areas.*

Recommendation 3.5: *Scientists and National Program Leaders should regularly confer with the Office of International Research Programs when planning projects to help ensure that possible opportunities for cross-national research cooperation are identified and exploited.*

Finding 3. There are opportunities to improve ARS' ability to undertake cross-program research.

We identify several factors that may constrain the ability of ARS NPLs and scientists to identify and exploit potential synergies across National Programs. These include: administrative burden on NPLs, physical separation of NPLs at ARS headquarters, limited or uneven travel funding available to ARS scientists, and deficiencies of the ARS R&D

Information System (ARIS). This report provides recommendations to address three of these factors.

Recommendation 3.6: *Increase the number and training of program analysts who support National Program Leaders (NPLs). These program analysts should be assigned to specific groups of NPLs to enable them to specialize in the issues related to the programs covered.*

Recommendation 3.7: *Take advantage of the forthcoming reorganization of office space at ARS headquarters to co-locate National Program Leaders from different National Program Areas operating in related scientific domains to facilitate interaction and information sharing.*

Recommendation 3.8: *Provide competitive funding for travel to support the building of scientific teams seeking to undertake cross-program, cross-location projects.*

Finding 4. There are opportunities to support high-risk, high-return research at ARS.
The study team identifies two complementary approaches to promoting high-risk, high-return (HR/HR) research.

1. **Change the standard R&D management processes to encourage everyone to undertake HR/HR research.** This approach has the potential to encourage more innovative riskier research on the margins, but is constrained by the fact that standard R&D management processes must serve multiple objectives, including helping to ensure basic quality and feasibility of proposals by all scientists.
2. **Create special programs focused on eliciting the efforts of risk-takers.** This approach focuses on creating opportunities to elicit the talent and energies of risk-takers and creative scientists. This approach, which is exceptional, is better suited to enabling HR/HR research.

Innovation inducement prizes are one example of the second approach to promoting HR/HR research. ARS has an internally focused innovation inducement program, called ARSX. The report offers one recommendation to improve that initiative.

Recommendation 3.9: *Augment the design of the ARSX initiative to include a multi-stage process that allows for progressively reducing the risks associated with ARSX projects to the point that further development can be handled through the standard research management processes.*

Recommendation 3.10: *Add a provision to the administration of the scientist performance evaluation system that credits participation in high-risk/high-return research initiatives, such as ARSX.*

Recommendation 3.11: *Create a mentoring program for early career ARS scientists interested in pursuing high-risk/high-return research. This program would include access to a network of successful scientists from within and outside ARS.*

Finding 5. ARS' funding process and National Program structure can impede efforts to build and coordinate enterprise R&D capabilities

ARS' funding process and National Program structure can be a barrier to building and coordinating enterprise capabilities. This is in part because both the funding process and the NP structure drives organizational norms for accountability and authority. The study team finds that 1) ARS lacks a coordinating entity or office in charge of enterprise capabilities efforts; and 2) ARS lacks a dedicated source of funding to support investments in enterprise-level capabilities for R&D.

Recommendation 3.12: *Strengthen efforts to build enterprise capabilities.*

This recommendation includes three options for ARS to strengthen its organizational and management capacity for building innovative enterprise capabilities for R&D. These options fall along a spectrum in terms of the degree of change they would entail, running from low to high.

- **Option 1 (low-change)** – Develop a systematic process for identifying, prioritizing and potentially budgeting enterprise-level requirements for enabling capabilities, such as data analytics.

- **Option 2 (medium-change)** – Establish an office with clear authority to coordinate and implement investments in enterprise-level capabilities.

- **Option 3 (high-change)** – Establish an office with clear authority to coordinate and implement investments in enterprise-level capabilities together with the creation of a dedicated pool of discretionary funding for such investments (Academy recommendations to build support for funding are discussed in Chapter 4.)

Recommendation 3.13: *Take advantage of the current hiring surge to pilot an enterprise approach to hiring and talent management.*

Recommendation 3.14: *Take advantage of the end of the USDA hiring freeze and the higher number of retirements expected in the near future to increase the diversity of the ARS scientific workforce through recruitment of a broader demographic.*

Recommendation 3.15: *Take greater advantage of term appointments in order to be responsive to new research developments while retaining flexibility to change direction as needed in a rapidly changing research environment.*

Finding 6. There are opportunities to enhance ARS' flexibility to make strategic research investments.

The following three characteristics of ARS' funding structure can limit flexible funding options: (1) research funding that is tied to the needs of particular stakeholder groups and locations; (2) research funding that is allocated by National Program; and (3) scientists that are base-funded.[1] This funding structure can limit ARS' capacity for strategic investments at an enterprise-level. The study team identifies several ways by which ARS' capacity can be narrowly focused and thus mission effectiveness can be negatively impacted.

Several recommendations in Chapter 3 address structural and programmatic opportunities to address two challenges facing ARS: (1) undertaking innovative and cross-cutting research; and (2) building enterprise-level capabilities to enable a more efficient and innovative research enterprise. The final component of enhancing this capacity is building support for the discretionary, enterprise-level funding needed to support strategic research investments.

With regard to the first challenge, the Academy offers two recommendations.

Recommendation 4.1: *Develop a strategy to build USDA, Office of Management and Budget (OMB), and congressional support for dedicated pools of competitive funding to enable HR/HR and cross-cutting research.*

Recommendation 4.2: *Take a more systematic approach to seeking and shaping potential 0500 account funding from Congress to use for strategic investment opportunities. This approach should:*

- Assess the benefits and challenges of different 0500 accounts
- Identify good practices for use of 0500 accounts, which include:

[1] By "base-funding", the study team means: When an organization has scientists whose salaries and research are funded by annual appropriations, and thus do not need to compete for external sources of funding, like in an extramural research program.

    - Competitive funds;
    - Available to ARS and outside researchers; and
    - Input from ARS to help ensure mission focus/integration of efforts.
- Determine research domains that would benefit from 0500 accounts
- Target outreach to relevant external stakeholder in support of flexible research funding

To address the second challenge, the study team offers a third recommendation.

Recommendation 4.3**:** *Develop a strategy to build USDA, Office of Management and Budget, and congressional support for a dedicated pool of funding for investment in enterprise-level capabilities.*

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Chapter 1 – Introduction

The Agricultural Research Service (ARS or the Agency) is the U.S. Department of Agriculture's (USDA) chief scientific in-house research agency, with a mission to deliver scientific solutions to address national and global agricultural challenges. ARS is widely recognized as the world's leading agricultural research organization, making major contributions across a wide range of agricultural fields. ARS is one of four agencies in USDA's Research, Education, and Economics (REE) mission area.[2] The Agency employs nearly 2,000 full-time scientists and engineers (including post doctorates), and nearly 4,000 support staff.

The Office of National Programs (ONP) within ARS uses scientific tools and delivers research-based solutions to address important issues with plants and animals. ONP oversees about 690 individual research projects through research units located in over 90 locations across the United States, Puerto Rico, and abroad. Researchers interface with farmers, producers, industry, and communities throughout the agricultural enterprise.

ARS is distinct from other USDA research agencies as it is an intramural research organization, which means it predominantly funds and conducts in-house research. Conversely, the National Institute for Food and Agriculture (NIFA) in REE is responsible for USDA's extramural research, which means that NIFA funds external researchers, primarily through grants.

In recent years, the Agency has recognized an imperative to adapt to scientific and technological advances in order to more effectively respond to increasingly fast-moving and complex agricultural research needs. In response to its changing research environment, ARS has conducted a number of innovative research and development (R&D) management initiatives, with varying degrees of success.

Other governmental research agencies contend with similar challenges and are implementing various solutions suited to agency needs. This report includes perspectives from several federal agencies, including the U.S. Environmental Protection Agency (EPA), the National Aeronautics and Space Administration (NASA), the National Institutes of Health (NIH). This report is also informed by information provided by four foreign governmental or international research institutions similar to ARS - the French National Institute for Agriculture, Food, and Environment (INRAE), Agriculture and Agri-Food (AAFC), Consultative Group for International Agricultural Research (CGIAR), and the Brazilian Agricultural Research Corporation (EMBRAPA).

[2] The other USDA REE agencies are the Economic Research Service, the National Agricultural Statistics Service, and the National Institute of Food and Agriculture.

Study Origin and Scope

ARS last implemented a major reorganization of its approach to research project and program management in 1996. This reorganization integrated disciplinary siloes and structured ARS to take a problem-centered approach to designing their research agenda. As a result, ONP was created to align and coordinate ARS research projects across the country on problems of high national or regional priority. The Agency aimed to make projects more impactful and leverage the Agency's resources more effectively.

Now, almost 25 years later, ARS is considering the merits to revitalize the national program structure and its R&D management processes. To that end, ARS contracted with the National Academy of Public Administration (the Academy) to perform an independent assessment of ONP. The assessment has three main scope elements:

1. Benchmark ONP program organization and management relative to other leading federal research agencies.
2. Collect informed external stakeholder views and views from leaders of ARS and its programs, as well as program staff, on directions for reforms and development.
3. Develop recommendations for organizational reforms based on documented findings.

In consultation with ARS leadership, the Academy study team identified the following core issues to explore in greater detail. These include how ARS can:

- Enable more innovative, riskier research, while continuing to do more commonly practiced problem-solving research to meet current challenges.
- Take fuller advantage of potential synergies across program areas, while continuing to meet distinctive program objectives and stakeholder needs.

Study Methodology

The Academy assembled a three-member Expert Advisory Group (EAG) of Academy Fellows to provide on-going strategic advice to the work of the Academy study team. EAG members provided extensive experience of the EAG members in the fields of science and technology program assessment, R&D management, and organizational design, the EAG (brief biographical information about EAG and study team members are in Appendix A).

The study team performed extensive research in the form of both primary and secondary data collection and analysis. Specifically, the study team reviewed a variety of documents relating to ARS including ONP plans, ONP annual reports, the ONP Cycle Handbook, travel policies, scientist performance evaluation policies, and presentations on ARSX (a research

program introduced to enhance quality research).[3] The study team also performed a literature search and examined related best practice materials on R&D management, organizational design, innovation, and characteristics of high-performing R&D organizations. Appendix B provides a selected bibliography of the literature and documents reviewed.

The study team interviewed more than 100 individuals, including current and former ARS leaders and scientists, National Program (NP) staff members, ARS Area Office staff, field scientists, and congressional stakeholder. In addition, the study team interviewed ARS customers and stakeholders for their input, convening two discussion group sessions attended by eight customer organizations to gain their views on various issues related to ARS activities, research products, research processes, external communication, and innovative work. Further, the study team conducted interviews with other USDA agencies, including NIFA, the Animal and Plant Health Inspection Service (APHIS), and the Natural Resources Conservation Service (NRCS).

In order to acquire a comprehensive perspective on the key issues in this study, the study team conducted several interviews with other federal agencies and private sector R&D programs. These interviews sought to gather additional perspective on the evolution of R&D management practices, practices for pursuing a balanced portfolio of high-impact research, and practices to address the challenges of monitoring and then facilitating cross-cutting research across large research portfolios. A complete list of the interviewees is provided in Appendix C.

Organization of the Report

In addition to this chapter, the report contains the following three chapters:

- **Chapter 2: The Characteristics and Changing Environment of ARS' Research Management Organization –** this chapter describes ARS R&D program structure; analyses the distinct characteristics of ARS research funding and each characteristic's advantages and challenges; examines the new context in which ARS must operate and the implications of that context for ARS; and details ARS' responses to its new context. This chapter provides context and key background information for a more detailed analysis of ARS R&D management presented in the following two chapters.
- **Chapter 3: Promoting Innovative and Impactful Research** – this chapter addresses opportunities for ARS to promote more innovative and impactful research, offering fourteen recommendations that are organized into three sections:

[3] The National Program Cycle Handbook documents the best practices for managing and working across the ARS matrix structure. The Handbook describes both what and how ONP does their work. It is not a policy and procedures document, but rather a collection of best practices for managing ARS research. The Handbook is a document internal to ARS. See Appendix D for information on the NP Cycle.

developing an enterprise-level R&D management strategy; promoting innovative research; and building enterprise capabilities.

- **Chapter 4: Building Support for Strategic Research Investments** – this chapter recommends two opportunities to build support for strategic research investments and to enhance the flexibility of ARS to more strategically invest at an enterprise-level.

Chapter 2 – The Characteristics and Changing Environment of ARS' Research Management Organization

This chapter provides summary background information on the ARS research organization to provide context for the findings and recommendations provided in this report. It is organized into four sections.

- **Responsibility and Authority for Research Management** – discusses the responsibilities and authority of program leadership and line management.
- **Research Funding** – highlights three characteristics of ARS research funding related to how it is appropriated and allocated, and discusses the characteristics' advantages and drawbacks for managing the research enterprise.
- **Changing Research Environment** – discusses important trends and developments that present opportunities and challenges for food and agricultural research organizations.
- **ARS Responses to the Changing Research Environment** – highlights key R&D management initiatives and other actions taken by ARS in response to the changing research environment.

Responsibility and Authority for Managing the R&D Organization

As a starting point, it is important to understand the lines of authority over the research enterprise as they exist within ARS. Responsibilities are divided between the Associate Administrator for Research Programs and the Associate Administrator for Operations (shown in Figure 1 below). The former Associate Administrator provides programmatic direction and guidance for ARS scientists, while the latter has line authority over staff and funding.

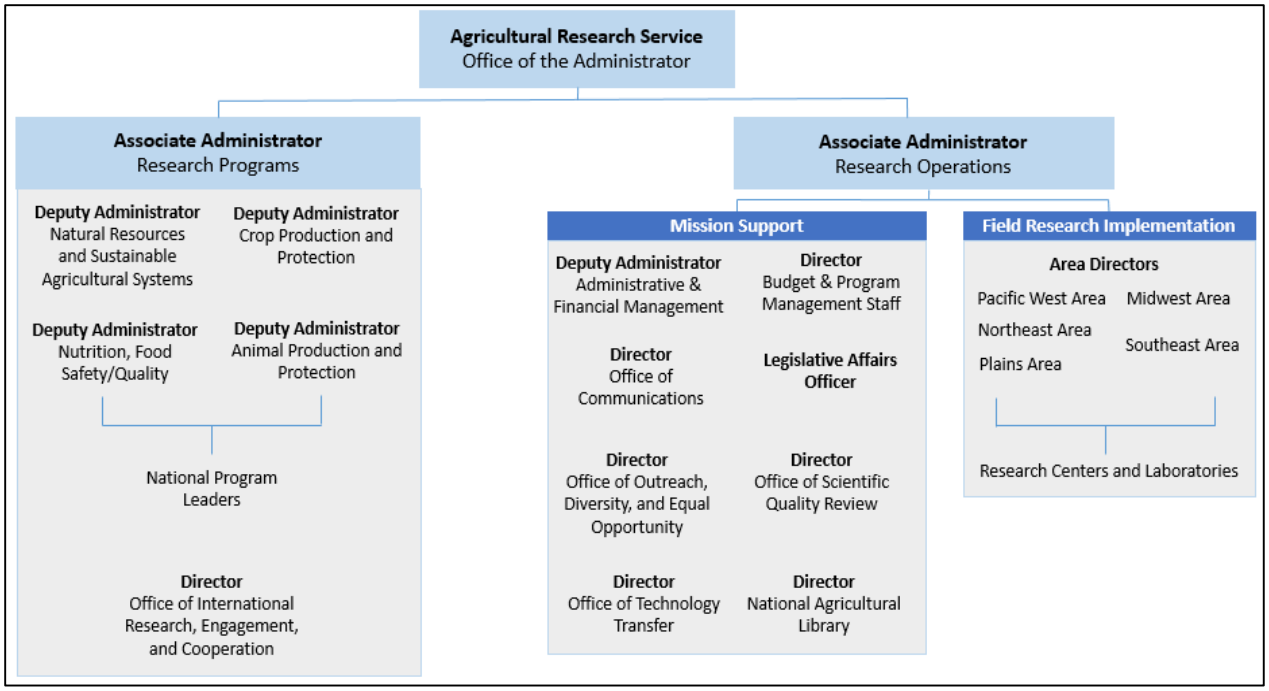

Figure 1. ARS Lines of Authority (Source: Created by the National Academy of Public Administration and Reviewed by ARS)

The Associate Administrator of Research Programs oversees four Deputy Administrators (DAs), each of whom oversees a National Program Area (NPA) that includes multiple National Programs. In total, there are 15 NPs. Figure 2 below presents the NPs by NPA.

National Program Leaders (NPLs) have direct responsibility for the planning and guidance of research that is funded within NPs. Currently, there are 22 NPLs (24 total, with two NPL positions currently unfilled) responsible for the 15 NPs that together encompass approximately 690 projects in Fiscal Year 2019. Each NP is the principal responsibility of one or two NPL(s). The principal NPL works collaboratively as part of a team with one or more NPLs from other NPs that are determined to have strong scientific linkages. In a few cases, NPLs from other NPs are formally vested with joint responsibility for an NP.

National Program Area	NP Title
Animal Production and Protection	Food Animal Production
	Animal Health
	Veterinary, Medical, and Urban Entomology
	Aquaculture
Natural Resources and Sustainable Agricultural Systems	Water Availability
	Soil and Air
	Grass, Forage, and Rangeland Agroecosystems
	Sustainable Agricultural Systems
Crop Production and Protection	Plant Genetic Resources, Genomics, and Genetic Improvement
	Plant Diseases
	Crop Protection and Quarantine
	Crop Production
Nutrition, Food Safety and Quality	Human Nutrition
	Food Safety
	Product Quality and New Uses

Figure 2. National Programs by National Program Area (Source: National Academy of Public Administration based on ARS data)

To accomplish NP objectives, NPLs work together with Area Directors (ADs), who have line authority over research centers and laboratories, including staff and resources. There are five geographic areas at ARS, and each have an Area office and an Area Director. The ADs are also responsible for some of ARS' 5-Year National Program Cycle (described further in Appendix D). While ONP provides direction on program and project level research objectives, the ADs are responsible for the operational planning and management of research locations in their Areas. They play a lead role in decisions about the allocation of staff and resources across locations, which have significant implications for the success of national program research activities.

ARS Research Funding

The Agency's funding structure has a significant impact on how the management of the research enterprise is executed. As an intramural research organization, ARS generally may only fund its internal workforce to conduct research.[4] Notwithstanding its internal focus, ARS has close connections to its customers and stakeholders. In fact, ARS' strengths and challenges are closely related to how they are funded. Before we review the three characteristics of research funding, we use the following few paragraphs to provide a brief

[4] ARS can use funds for external use. Sometimes Congress mandates funds for research with external partners.

summary of explaining basic information on how research funding is appropriated and allocated in the field.

In Fiscal Year 2020, ARS received an appropriation of $1.61 billion (see Figure 3 below for the last 10 years of ARS appropriations). ARS receives a single appropriation each year for all expenses associated with performing research.[5]

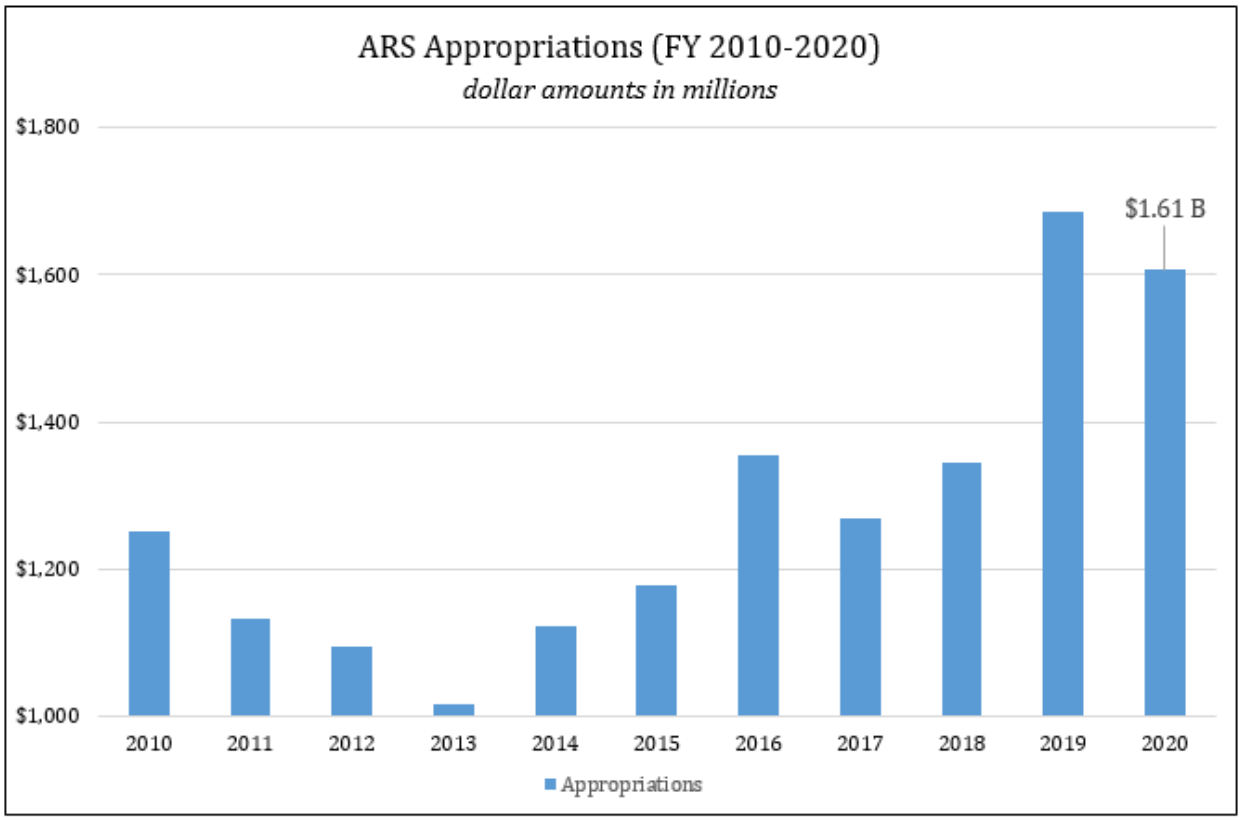

Figure 3. ARS Appropriations from FY2010-FY2020. (Source: Chart created by the National Academy of Public Administration, based on appropriations data from the Congressional Research Service)[6]

Each year's appropriation from Congress is accompanied by a Conference Report that provides the funding Committee's recommendations on how the budget resources should be

[5] Increases observed in appropriations for fiscal years 2019 and 2020 consist largely of substantial investments in buildings and facilities, including the planned National Bio and Agro-Defense Facility (NBAF). NBAF will be operated under the Department of Homeland Security, in partnership with ARS, and will replace ARS' Plum Island Animal Disease Center in New York. The facility is expected to be fully completed by 2023.

[6] Monke, Jim, Randy Alison Aussenberg, Megan Stubbs, Susan Thaul, Renee Johnson, Joel L. Greene, and Tadlock Cowan. 2011. *Agriculture and Related Agencies: FY2012 Appropriations.* Washington, DC: U.S. Congressional Research Service. https://crsreports.congress.gov/product/pdf/R/R41964.; Monke, Jim, Mark A. Mcminimy, Megan Stubbs, Randy Schnepf, Randy Alison Aussenberg, Agata Dabrowska, Joel L. Greene, et al. 2016. *Agriculture and Related Agencies: FY2016 Appropriations.* Washington, DC: U.S. Congressional Research Service. https://crsreports.congress.gov/product/pdf/R/R44240.; Monke, Jim. 2020. *Agriculture and Related Agencies: FY2020 Appropriations.* Washington, DC: U.S. Congressional Research Service. https://crsreports.congress.gov/product/pdf/R/R45974.

used, reflecting the particular needs of different customers and stakeholders. Until the end of congressional earmarking in 2011, appropriations language also often directed new research funding to a specific ARS research location.[7] While appropriations are no longer directed to particular locations, congressional intent continues to direct appropriations based on the research focus. For example, in the FY19 Senate Report, the Committee directed ARS to continue its Atlantic salmon breeding and domestication work. The Senate report continued: "*the Committee notes that domestic salmon farms are required to only use strains of salmon that are of North American origin and that these strains need substantial breeding improvement in order to be competitive with strains currently used by foreign producers. The Committee notes that the current ARS Atlantic salmon breeding program lacks a geneticist and supports efforts by the Department to address this need.*"[8]

ARS allocates appropriated research funds to any one of its 93 research locations based upon the match between the purposes articulated in congressional language and the subject matter focus of research activities at particular locations. These variables are factored in when evaluating resource requirements for undertaking needed research. Projects are typically coded to only one NP; the sum of funding for projects assigned to each NP accounts for the total allocation by NP, as shown for FY 2019 in Table 1, below.

Animal Production and Protection	
Title	**Allocation**
Food Animal Production	$57,311,400
Animal Health	$80,962,800
Veterinary, Medical, and Urban Entomology	$20,791,700
Aquaculture	$37,739,500

Nutrition, Food Safety/Quality	
Title	**Allocation**
Human Nutrition	$88,354,500
Food Safety	$99,240,600
Product Quality and New Uses	$108,045,400

Natural Resources and Sustainable Agricultural Systems	
Title	**Allocation**
Water Availability	$76,890,400
Soil and Air	$43,736,100
Grass, Forage and Rangeland Agroecosystems	$47,937,700
Sustainable Agricultural Systems	$60,838,200

Crop Production and Protection	
Title	**Allocation**
Plant Genetic Resources, Genomics and Genetic Improvement	$211,479,400
Plant Diseases	$82,787,000
Crop Protection and Quarantine	$111,822,200
Crop Production	$45,468,000

Table 1: Funding Allocation by National Program (FY2019). (Source: Agricultural Research Service)

In light of the processes articulated above, the study team identifies three characteristics of ARS research funding that have both advantages and challenges for managing the research

[7] Since the 110th Congress (2007-2008), House and Senate rules have defined an earmark as any congressionally directed spending, tax benefit, or tariff benefit that would benefit an entity or a specific state, locality, or congressional district. In the 112th Congress (2011-2012), the House and Senate began observing what has been referred to as an earmark moratorium or earmark ban. (Source: https://crsreports.congress.gov/product/pdf/R/R45429).

[8] 115th Congress, U.S. Senate. 2019. "Senate Report 115-259 - Agriculture, Rural Development, Food and Drug Administration, and Related Agencies Appropriations Bill, 2019." Washington, DC. https://www.congress.gov/congressional-report/115th-congress/senate-report/259/1.

enterprise. The following three characteristics help provide insight into the ability of ARS to respond to opportunities presented by changes in the research environment.

- Research funding is tied to the needs of particular stakeholder groups and often to particular locations;
- Scientists and projects are funded under individual national programs; and
- Scientists and projects are base-funded.[9]

Advantages and challenges of each characteristic are analyzed below. In general, the study team finds that these characteristics constrain ARS' flexibility at an enterprise-level.

Research Funding Tied to the Needs of Particular Stakeholder Groups and Locations
Appropriations for most ARS research project specify, to varying degrees, the focus of research to be funded. Research focus reflects the perceived needs of particular stakeholder groups. Until recently, appropriations often also specified the location where the research is to be conducted. With the end of congressional earmarking, research dollars are no longer appropriated to particular locations. However, much ARS research funding is still tied to specific locations because those locations have the necessary capabilities to perform the research specified in the accompanying Conference reports authorizing ARS appropriations.

- **Advantage** – This approach can help ensure that ARS is responsive to the particular needs of its stakeholders. In combination with ARS' diversity of research locations (93 locations), this approach also enables ARS to closely connect with a large number of diverse agricultural communities in many different states and localities.
- **Challenges** – This can limit the ability of ARS to invest in (1) cross-cutting research that spans disciplines and locations; and (2) research that addresses problems facing the broader agricultural community, and not a single stakeholder. In addition, this approach can hinder the ability of ARS to invest in enterprise-wide capabilities such as data management and data analytics that would enable efficiencies and synergies across research efforts. Another challenge is that it can hamper ARS' ability to close research locations or sunset Current Research Information System (CRIS) projects that continue to be funded by appropriations.[10]

[9] Base-funded: Scientists whose salaries and research are funded by annual appropriations, and thus do not need to compete for external sources of funding, like in an extramural research program.
[10] ARS can close a research location but congressional approval is needed. Also, ARS has some latitude to redirect research.

Research Funding is Allocated by National Program

It is commonplace for research enterprises of significant size and breadth to organize around programs in order to enhance subject matter focus and promote mission accountability.[11] ARS is not an exception, and is organized by NP. Although Congress does not appropriate ARS' funding by NP, research funding is internally allocated by NP.

- **Advantage** – This enables depth of subject matter focus, ensures accountability for projects, and provides management clear line of sight into use of Agency resources.
- **Challenges** – Since projects are almost always assigned to a single NP, funding cannot readily be shared across programs. At times, this can artificially constrain cross-program research contributing to stove-piping of research and knowledge. Furthermore, because this NP structure provides accountability and management line-of-sight into projects, in the worst case scenario NPLs may resist cooperative efforts that take resources and staff time away from projects they are responsible for, especially in the context of tight budgets.

Scientists are Base-Funded

As previously discussed, ARS' scientists are base-funded, which means that Congress provides an appropriation to the Agency to fund both scientists' salaries and their research. Congress does not directly appropriate funds for specific research projects, though congressional intent may encourage ARS to use funds for particular kinds of research.

- **Advantages** – Base-funding for scientists is generally acknowledged within and outside of ARS as a major advantage. It enables sustained focus on research problems over long time horizons, because ARS scientists have reason to be confident that their research will be funded. Unlike university scientists and researchers in extramural organizations, ARS counterparts generally do not have to invest time applying for short-term (generally single-year) funding and cobbling together diverse funding sources with, sometimes, different objectives in order to pursue work on a research problem over time.
- **Challenge** – This can contribute to inertia by enabling research projects to continue on despite limited or diminishing returns.

Changing ARS Research Environment

In recent years, ARS' research environment has changed substantially due to scientific and technical progress in the broader community. The study team's analysis highlights three trends and developments in science, technology, and society that present major

[11] Large research organizations studied by the study team were generally organized around programs. These organizations include EPA, NOAA, NIH, NASA, EMBRAPA, and INRA.

opportunities and challenges for an agricultural research organization like ARS.[12] These include:

- **Cross-cutting capabilities and approaches developed outside of the traditional agricultural research community**. New capabilities and approaches have been developed that cut across traditional agricultural research domains and have the potential to enable much more rapid and higher impact research. These new capabilities include:
    - The development and validation of precise field-deployable sensors and biosensors that enable rapid detection and monitoring capabilities across various food and agricultural disciplines; and
    - The application and integration of data science, software tools, and systems models that will enable the ability to more quickly collect, analyze, store, share, and integrate highly heterogeneous datasets, creating opportunities to greatly increase the impact of food and agricultural research.
- **New and growing concerns in different areas call for greater integration of research across disciplines and domains.** Industry challenges have always been interdisciplinary, but new and growing concerns in a number of areas, such as environment, nutrition and food safety have increased the importance of integrating diverse domains of research.
- **Traditional lines of technical advance are yielding diminishing returns or generating negative externalities**. For example, soy bean breeding has reached limits in terms of high water use and harms caused by the pesticides used.[13]

ARS Reponses to the Changing Research Environment

In response to the changing research environment, ARS has experimented with a variety of innovative R&D management initiatives to increase the impact of ARS research investments. ARS leadership has taken advantage of opportunities like retirements and hiring freezes to change up staffing and seed various R&D management initiatives. These initiatives have been undertaken in an ad hoc manner, largely reflecting the limitations of how ARS research is funded. Six of the most recent initiatives are briefly described below (more information is provided in Appendix E).

- **ARSX** – This initiative is intended to promote high-risk/high-return research aimed at addressing major agricultural challenges.

[12] These developments have been articulated most recently in: The National Academies of Sciences, Engineering, and Medicine. 2019. *Science Breakthroughs to Advance Food and Agricultural Research by 2030.* Washington, DC: The National Academies Press. doi:https://doiorg/10.17226/25059.

[13] ARS has sought to respond to this challenge by changing the breeding objectives of genetic selection in soybeans.

- **ARS Synergies (formerly Grand Challenges)** – This initiative aims to enable the integration of existing projects in different national programs that offer the potential for synergy benefits greater than the transaction costs entailed.
- **Breeding Insights** – ARS-funded project with Cornell University to make new genetic improvement capabilities available to smaller plant breeding research efforts across ARS.
- **Partnerships for Data Innovations** – Stemming initially from a charge to build engineering capacity across the enterprise, this initiative shifted to a more integrated approach to data management (moving from "small data" silos across the organization to "big data" that could be leveraged across the enterprise) and most recently also incorporated automation, and analysis of data collected by sensors geared toward enabling "precision agriculture."
- **SCINet** – An effort at ARS to improve USDA's research capacity by providing scientists with access to high performance computer (HPC) clusters, cloud computing, improved networking for data transfer, data storage and training in scientific computing.
- **Virtual AI Center of Excellence** – A center of excellence to build on ARS' current high performance computing environment and SCINet, and look to buy, rather than build, a common AI platform and toolboxes.

Summary

Its funding model, organizational structure, and program cycle has enabled ARS to sustain its problem-focused approach to R&D for thousands of customers and stakeholders throughout the nation and beyond our borders, and has contributed to the Agency's respected position in the world of plant and animal, and nutrition and environment research. Besides the hundreds of highly qualified scientists who have been recruited to the Agency, key structural enablers of ARS' success include:

- Stable funding that allows ARS scientists to formulate and conduct research with, at a minimum, 5-year time horizons.
- Geographically-distributed organization, customer-driven funding, and domain-specific NPs enhance the Agency's ability to consistently perform research that is immediately valuable for a wide range of customers across the United States.

However, continuing scientific and technical progress has changed ARS' research operating environment, providing opportunities for ARS to increase the impact of its agriculture research on meeting the challenge of feeding a growing global population. The Agency has made significant efforts to exploit these opportunities through new initiatives, pilot programs, and partnerships. Nevertheless, such efforts to adapt to the changing research

environment have also been limited somewhat by ARS' funding model, organizational structure, and strategic direction.

The following two chapters contain seventeen recommendations, organized into the following three categories that target opportunities to improve ARS mission impact:

1. Developing an enterprise-level strategy for managing and communicating innovative R&D management initiatives;
2. Optimizing the organizational structure to promote more innovative research and building of enterprise capabilities; and
3. Building support for strategic research investments.

Chapter 3 will address the first and second categories of recommendations, and Chapter 4 will address the third.

Chapter 3: Promoting Innovative and Impactful Research

This chapter addresses opportunities for ARS to promote more innovative and impactful intramural research, focusing on the innovative R&D management initiatives described at the end of the previous chapter. It is organized into three primary sections, in which the study team makes fifteen recommendations. The three sections in this chapter are as follows:

- **Developing an Enterprise-Level R&D Management Strategy** – identifies opportunities to enhance ARS' overall R&D management strategy and makes two recommendations targeted at developing a more effective enterprise-level strategy for organizing and communicating its R&D management efforts.
- **Promoting Innovative Research at ARS** – discusses impediments to innovative research at ARS, and makes five recommendations on how to promote more innovative and impactful research.
- **Supporting Innovative Research by Enhancing Enterprise Research and Development Capabilities** – assesses ARS' efforts to build innovative enterprise capabilities and identifies impediments to those efforts.

Developing an Enterprise-Level R&D Management Strategy

A fundamental role for the management of an R&D organization is to develop a vision and coherent strategy that guides and structures the efforts of the entire agency. A 2012 National Research Council (NRC) report on best practices for federal R&D organizations identified two key tasks for the managers of an R&D organization:

1. Establishing the vision and strategic plan for the organization; and
2. Ensuring the preparedness of the organization to meet current commitments and future opportunities.[14]

A 2014 NRC report went further, saying: "Every science institution is more effective if it has a vision of how its scientists, technicians, and other professionals can best contribute to the organization's mission and goals."[15]

In response to changes in its research environment (discussed at the end of Chapter 2), ARS leaders have experimented with a variety of innovative R&D management initiatives. While

[14] The National Academies of Sciences, Engineering, and Medicine. 2012. *Best Practices in Assessment of Research and Development Organizations.* Washington, DC: The National Academies Press. https://www.nap.edu/catalog/13529/best-practices-in-assessment-of-research-and-development-organizations.

[15] The National Academies of Sciences, Engineering, and Medicine. 2014. *Rethinking the Components, Coordination, and Management of the U.S. Environmental Prtoection Agency Laboratories.* Washington, DC: The National Academies Press.

each of these initiatives is promising, the study team identifies a number of critical success factors and provide an assessment of ARS implementation.

- **Clarity about how innovative R&D management initiatives fit together with each other in a broader R&D management strategy to achieve impact.** Unclear priorities can hinder ability to manage initiatives as a broader, balanced portfolio. It is not clear how they fit together as part of an integrated, larger R&D management strategy. This can hinder the ability of ARS managers to coordinate and invest in these initiatives as a unitary portfolio, assigning priority to various pieces, and investing accordingly. While there is no generally accepted definition of innovation, one the study team identifies as pertinent is impact.
- **Communication of innovative R&D management initiatives**. Initiatives have been undertaken on an *ad hoc* basis, reflecting, in part the availability of funding. The objectives of some of these initiatives have evolved over time. Based on the interviews by the study team, field scientists have an uneven understanding of the objectives, benefits, and processes for many of these innovative initiatives, like ARSX and Synergies. This is due partly to the fact that communication for these initiatives has been collateral duty for ONP staff members leading them.
- **Focus on lower-risk opportunities to enhance impact**. These initiatives have primarily emphasized high-risk, high-return (HR/HR) research, with no explicit attention to opportunities for lower-risk, high impact research. One example is the Breeding Insights initiative, which potentially enables lower-risk investments. However, there is not a clear focus on this investment category.

These initiatives may be understood in terms of two different, but related, objectives, but each with the overarching aim of increasing potential impact of ARS research investments. The two objectives are: (1) promoting innovative research; and (2) building enterprise capabilities. Table 2, below, groups six of ARS' most recent initiatives, based on these two objectives.

Objective	ARS Initiative	Description of Initiative
Promoting Innovative Research	ARSX	Intended to induce high-risk/high-return research aimed at addressing major agricultural challenges
	Synergies / Grand Challenges	Intended to enable the integration of existing research projects in different national programs that offer the potential for synergy benefits greater than the transaction costs entailed; systematic, but geared toward incremental, lower risk, but potentially high-impact research.
Building Enterprise Capabilities	Breeding Insights	Intended to make new genetic selection capabilities available to plant breeding research efforts across ARS.
	Partnerships for Data Innovations	Central repository for ARS data, data visualization, overall standardization and user-friendly access to data for researchers.
	SCINet	An effort at ARS to improve USDA's research capacity by providing scientists' access to high performance computer (HPC) clusters, cloud computing, improved networking for data transfer, and training in scientific computing.
	Virtual AI Center of Excellence	This center of excellence will build on ARS' current high performance computing environment, SCINet. and looks to buy rather than build common AI platform & toolboxes.

Table 2: Six Innovative R&D Management Initiatives at ARS (Source: National Academy of Public Administration)

This report makes two recommendations aimed at bolstering the long-term impact of these innovative initiatives.

Recommendation 3.1: *Develop an enterprise strategy for innovative R&D management initiatives.*

ARS should develop a strategy that clearly communicates to the entire organization the objectives of its various R&D management initiatives and how they fit together as part of an overall enterprise strategy for achieving greater mission impact. The strategy should do the following things:

- Group the initiatives;

- Clarify the objectives for each initiative;
- Identify connections between initiatives and normal NP research; and
- Communicate how the portfolio of initiatives fits into the organization's broader goals and efforts.

Recommendation 3.2: *The R&D management strategy should include a balanced portfolio for achieving impact with a focus on high-risk/high-return research.*

- **Impact should be the overarching goal.** All research in the portfolio does not need to be high risk to be high impact. There are different means of getting to high impact. One aspect of strategy should be taking benefits of high risk research, and making tools available for enabling more efficient research throughout the ARS enterprise (i.e. Breeding Insights).
- **Focus on impact should be combined with a balanced portfolio approach.** ARS should clearly prioritize initiatives according to their potential impact, invest in these initiatives based on the impact-based prioritization, and then communicate the priority and investment plan to the entire organization. A standard consideration in this balanced portfolio approach would be to ensure a healthy mix of risks.

Promoting Innovative Research

In this section, we discuss general types of impediments to innovative research and opportunities to address these impediments in the particular context of ARS. The section is organized into four parts.

1) Impediments to innovative research – insularity, barriers to cross-cutting research, and risk aversion
2) Opportunities to mitigate insularity
3) Opportunities to enable cross-cutting research
4) Opportunities to enable high-risk/high-return research

Impediments to Innovative Research

There is no single generally accepted definition of innovative research.[16] However, in our literature review on innovative research, we identified three general types of impediments to innovative research. These are:

[16] Zuckerman, Brian L., Judith A. Hautala, and Rashida Nek. 2015. *Technology Development at the National Institutes of Health (NIH): Summary Report.* Washington, DC: Institute for Defense Analysis: Science & Technology Policy Institute. https://www.ida.org/-/media/feature/publications/t/te/technology-development-at-the-national-institute-of-health-nih-summary-report/d-5712.ashx.

1. Insularity
2. Barriers to cross-disciplinary research
3. Risk aversion

Opportunities to Mitigate Insularity

Insularity is an important concern for an intramural research organization, as it relies on its own research staff. However, the emergence of new and powerful approaches outside the traditional agricultural research community, makes it all the more important to ensure that ARS is doing what it can to tap into outside expertise and perspective.

Good practice research suggests opportunities to mitigate insularity bringing in leading technical experts from outside the organization on a more regular, term-limited, basis. The regular rotation of outside experts into research program leadership positions helps ensure the regular injection of fresh perspective and cutting-edge expertise. This practice is closely associated with two widely-respected R&D organizations, the National Science Foundation and the Defense Advanced Research Projects Agency (DARPA).

ARS ONP leaders have sought to tap external expertise and perspective by hiring NPLs from outside the organization. At this writing, over half of current NPLs (12 of 22) were hired from outside the Agency, however, this has not been done on a regular basis.

While generally considered a key factor in the success of these extramural research organizations, the adoption across the board would not be appropriate to an intramural research organization like ARS. The value of bringing in outside perspectives through the use of external professionals for a temporary assignment should be balanced with other considerations. These include the preservation of career development options for intramural scientists and the benefit of have having former NPLs taking a broadened perspective back out into the field.[17] Also, it is important to have internal staff who understand how the Agency's R&D research enterprise works to balance a new perspective with a practical understanding of how to realize change in the system. While the exact balance is necessarily a judgement call, it has been suggested by some interviewees that a large dose of external hires may be needed to change the culture.

[17] Former Forest Service R&D officials discussed these benefits of internal rotation in interviews for NAPA study performed for Forest Service R&D in 2019. This practice was discontinued some years ago for unrelated reasons, including the lack of new money for R&D, which made the service in research program leadership positions less attractive. The NAPA study can be found at: Dominguez, Michael, David Birdsell, Thomas Kane, Michael Lipsky, Kay Goss, and Steven Redburn. 2019. *Organizational Assessment for U.S. Forest Service Research & Development.* Washington, DC: The National Academy of Public Administration. https://www.napawash.org/studies/academy-studies/us-forest-service-assessment-of-research-development-function.

Recommendation 3.3: *Adopt a system of regular rotation for National Program Leaders that includes a mix of external and internal personnel.*

Good practice research also suggests an opportunity to mitigate insularity through the use of external expert review of intramural research programs. It is common practice for federal research agencies to employ external expert panels to review their research programs.

ARS has long employed various mechanisms for external review of its research activities. These include prospective review of individual research projects by external scientists and retrospective review of national research program results by external stakeholders including industry and university participants (see Appendix E for fuller discussion of these mechanisms). However, ARS does not systematically employ groups of external experts to review opportunities to exploit potential linkages across NPs and National Program Areas (NPAs).

Several federal agencies employ external expert review panels in evaluating their research program plans. One of these agencies, EPA's Office of R&D (ORD), offers a long-standing, successful precedent for using external expert review of intramural research programs. The EPA's ORD maintains a Federal Advisory Committee Act (FACA) committee referred to as the Board of Scientific Counselors (BoSC). The BoSC and its subcommittees undertake regular reviews of ORD research programs providing feedback on the program plans as well as gaps in research between program plans.[18] These reviews have two aims, to help ensure that ORD research programs are taking full advantage of (1) the latest scientific and technical developments; and (2) potential synergies across programs.

The first aim is less relevant to ARS. Unlike EPA's ORD, ARS has a long-standing process for expert external review of research projects. Also, if the Academy recommendation to institute a regular process of rotating NPLs is implemented, ARS also will have the benefit of external perspective in developing NP five-year action plans. However, the second aim complements the purpose of Academy recommendations offered in the following subsection that intend facilitate the identification and exploitation of potential synergies across NPs.

[18] Under prior Administrations, the strategic action plans developed by ORD's research programs were also reviewed by the Science Advisory Board (SAB). The Science Advisory Board, which is a Federal Advisory Act committee that supports the Administrator, would look at the plans from the perspective of Agency mission and the priorities of the Administrator – and how the research fits in the overall portfolio of Agency actions. The BoSC would then review for the technical content and implementation of the plans. Recently, the SAB has been undergoing restructuring, so the BoSC is reviewing programs from both perspectives-- strategy and implementation.

Recommendation 3.4: *Institute a regular process for prospective external expert review of ARS National Program 5-year plans that focuses on identifying potential synergies across National Programs, especially National Programs in different National Program Areas.*

While the U.S. leads the world in many areas of agricultural research, other countries have developed particular research strengths that ARS researchers could better build upon. However, some of these opportunities may be left unexploited given the lack of a systematic process for engaging experts in the Office International Research Programs (OIRP) during the process of developing project plans. OIRP, which is responsible for enabling international cooperation in agricultural research can help identify opportunities for collaboration and avoid unnecessary duplication of effort.

Recommendation 3.5: *Scientists and National Program Leaders should regularly confer with Office of International Research Programs when planning projects to help ensure that possible opportunities for cross-national research cooperation are identified and exploited.*

Opportunities to Improve Ability to Undertake Cross-Program Research

We identified the following factors constraining the ability of ARS NPLs and scientists to identify and exploit potential synergies across NPs. These include:

- Administrative burden on NPLs
- Limited interaction of NPLs across national program areas
- Uneven travel funding available to ARS scientists
- Deficiencies of the ARS R&D Information System (ARIS)
- Administrative and funding factors hindering cross-program projects

<u>Administrative Burden on NPLs</u>

NPLs play a key role in identifying and exploiting potential opportunities for cross-cutting research. As noted in Chapter 2, NPLs are not only responsible for individual NPs, but also are expected to look for potential synergies between projects in different NPs. This expectation is reflected in the informal team approach to managing individual NPs (discussed in Chapter 2).

However, our research suggests that NPLs lack adequate time to identify and exploit potential synergies across programs and to carry out their core program leadership responsibilities due to undue administrative task volume. NPLs report that that they spend a large, and increasing, part of their time on administrative matters. They identify the most time-consuming obligations to include meeting logistics and responding to internal and external queries, as well as interagency assignments. Inefficient processes and the lack of

user-friendly, shared, information systems (discussed below) also divert NPL attention away from mission-critical focus.

While the study team is unable to perform a detailed analysis of administrative burden, but it appears clear that the level of support staff available to NPLs is inadequate for optimal use of NPL expertise dedicated to program leadership as opposed to administrative tasks.[19] In each National Program Area, NPLs share only one, maximum two, administrative assistants and program analysts. Not only is this support staff team at the Agency too small, but the support staff generally lacks the technical background or training to be useful in some routine, but important, support tasks such as note taking and background research.

Further, it is often noted in interviews that a past effort to create a pool of support staff serving all NPLs was not successful. The pooled approach prevented support staff from being able to specialize in the particular needs of different program areas. A consensus conclusion among interviewees on this point was that, to be effective, support staff members should be grouped by related NPs to enable them to become familiar with the subject matter and particular issues of these NPs.

Although it is not feasible to estimate the optimal number and training of NP support staff or to explore the specifics of other potential time-savers (e.g., process efficiencies), it is imperative that support staffing and systems be improved to enable more time and attention to be devoted to core program leadership responsibilities. If the NPL position is associated with heavy administrative demands, it may become increasingly challenging for ARS to recruit and retain top science talent to serve in NPL positions.

Recommendation 3.6: *Increase the number and training of program analysts who support National Program Leaders (NPLs). These program analysts should be assigned to specific groups of NPLs to enable them to specialize in the issues related to the programs covered.*

Limited Interaction of NPLs across National Program Areas

As discussed in Chapter 2, ARS takes a team approach to managing NPs, with the principal NPL working collaboratively with one or more NPLs from other NPs that are determined to have strong scientific linkages. However, while collaboration among NPLs within individual National Program Areas (NPAs) is common, collaboration among NPLs across the four NPAs is more limited despite important scientific linkages.

[19] An examination of administrative burden might include the following: an analysis of sign offs needed for activities, amount of time required for administrative pass through of various core activities, rules-forecast charts (relating rules objectives to compliance requirements to predicted behavior change to actual outcomes and impacts) and rules charting identifying relation of mandates for organizations' own rules and norms. See Pandey, S. K., & Scott, P. G. (2002). Red tape: A review and assessment of concepts and measures. *Journal of Public Administration Research and Theory*, *12*(4), 553-580.

A near-term opportunity to facilitate information sharing among NPLs in different NPAs is offered by the forthcoming reorganization of ARS headquarters space. While this consolidation presents challenges for NPLs such as the loss of private offices, it also offers the opportunity to foster more interaction among NPLs across NPAs by co-locating NPLs in different NPAs operating in inter-related scientific domains. Of course, the linkages to be exploited will change over time and the location of NPLs will need to be reconsidered on a regular basis and supplemented by processes to help ensure interaction among NPLs operating in related scientific domains. However, factoring in consideration of linkages among NPAs into the reorganization of office space offers on easy way to improve the ability of ARS to identify and exploit potential synergies.

Recommendation 3.7: *Take advantage of the forthcoming reorganization of office space at ARS headquarters to co-locate National Program Leaders from different National Program Areas operating in related scientific domains to facilitate interaction and information sharing.*

Uneven Travel Funding Available to Scientists

Funding available to working scientists in the field reflects historical funding allocations as discussed in Chapter 2. In short, the availability of funding for travel varies across projects and locations. This variability can be a constraint on the identification and exploitation of potential synergies across programs and locations depending on the resources available to would-be participants.

Productive scientific working relationships depend on trust and mutual understanding that foster a willingness to share information and resources. Such relationships are cultivated most effectively through in-person interaction.[20] Where would-be collaborators are in different locations separated by significant distance, the inability to travel can hinder the establishment of effective working relationships.

In recent years, the availability of low cost, high-quality video conferencing has greatly reduced the need for travel by enabling face-to-face communication remotely. The restrictions on air travel and in-person meetings during the COVID – 19 Pandemic have accelerated the adoption of videoconferencing making clear that remote communication and increased the comfort level with this technology.

[20] Research done by the Massachusetts Institute of Technology's Human Dynamics Laboratory looking more generally at the performance of teams identified three crucial elements of communication of high-performing teams and organizations: energy, engagement, and exploration. Face to face exchanges and social interaction across an organization and its teams were identified as two primary drivers of creativity and performance. Pentland, Alex. 2012. *The New Science of Building Great Teams.* April. Accessed May 25, 2020. https://hbr.org/2012/04/the-new-science-of-building-great-teams.

However, while video conferencing can greatly reduce the need for travel, it does not substitute for in-person interaction, especially in the early stages of relationship building. While teleconferencing has been put to good use during the COVID – 19 Pandemic, its effectiveness depends significantly on good working relationships already in place.

Deficiencies of the ARS R&D Information System (ARIS)

The ARS R&D Information System (ARIS) provides a range of information about research projects. In principle, this system should enable NPLs and ONP leaders to assess the enterprise portfolio and identify opportunities for cross-program synergies. However, interviews indicate that the system does not provide the quality and consistency of information needed to make such assessments. Also, the system is generally reported to be very cumbersome to use. As a result, NPLs, if they use the system at all, rely on program analysts to extract information from the information system, and NPLs generally discount the idea of ARIS as a tool for portfolio analysis and management. Instead, it is seen as an inefficient "tool" absorbing valuable time that could be invested into core program leadership responsibilities.

A sister agency to ARS, Brazil's EMBRAPA, has recently updated its project database and developed user-friendly information technology solutions to enhance access to a range of information on research projects across the enterprise. ARS may benefit from examining this effort.

However, there are newly developed technology-based opportunities to improve enterprise-level assessment and management of the R&D portfolio. The ARS National Agricultural Library (NAL) is piloting the application of machine learning, natural language processing, techniques to assist in assessing program and project information available on ARS research efforts.[21]

Natural language processing provides a powerful complement to direct human assessment of information by enabling a more efficient, automated approach. The NAL approach, which applies natural language processing to ARS information available in current formats will help identify further opportunities for potential synergies within and across NPs.

[21] "Natural Language Processing (NLP) is a way of analyzing texts by computerized means. NLP involves gathering of knowledge on how human beings understand and use language. This is done in order to develop appropriate tools and techniques which could make computer systems understand and manipulate natural languages to perform various desired tasks," from: Joseph, Sethunya R, Hlomani Hlomani, Keletso Letsholo, Freeson Kaniwa, and Katlwano Sedimo. 2016. "Natural Language Processing: A Review." *International Journal of Research in Engineering and Applied Sciences* 6 (3).

The application of natural language processing techniques to portfolio analysis for the Gates Foundation offers good practice guidance that goes beyond current ARS efforts.[22] However, this practice will require additional investment. The ARS approach overlays machine learning to source existing publications that are not systematically indexed. In contrast, the approach employed by the Gates Foundation depends on standardized and synthesized project data on spreadsheets, to which machine learning is then applied.[23]

Administrative and Funding Constraints on Undertaking Cross-Program Projects

Where potential synergies have been identified, undertaking cross-program research projects may be hindered by a number of factors. NPLs and scientists identified the following factors:

- Lack of alignment across NP planning cycles
- Administrative requirement that projects be assigned to a single NP
- NPL concerns about sharing staff resources
- Lack of funding to support additional work required for success

As discussed in Appendix D, the planning and evaluation cycle for the 15 NPs occurs on a staggered basis. This makes it difficult to plan a joint project across NPs in different phases of the cycle.

In order to enable the tracking of resources and accountability for performance, projects must be assigned to a single NP. Doing so can contribute to reluctance by NPLs to support cross-program projects that entail significant sharing of staff time and resources. Rightly or not, some NPLs may be concerned that sharing resources with a project assigned to another program could compromise the success of projects they are responsible for while offering uncertain benefits. It is important to address these reasonable concerns with the countervailing aim to enhance synergistic, cross-program research initiatives.

Cross-program projects often entail significant investment of time into building and maintaining relationships between researchers in different locations who have not worked together in the past. As noted earlier, building successful working relationships depends on trust and mutual understanding that generally require some significant in-person interaction. In the case of researchers in different locations who have not worked together before, some amount of travel and therefore resources are required to enable this interaction and relationship building.

[22] University of Washington: Evans School of Public Policy & Governance. 2020. *Portfolio Reviews.* May 14. https://evans.uw.edu/policy-impact/epar/portfolio-reviews.

[23] University of Washington: Evans School of Public Policy and Governance. n.d. *Text Analysis.* Accessed May 14, 2020. https://evans.uw.edu/policy-impact/epar/text-analysis.

To help address the difficulties of undertaking cross-program projects, ARS developed the ARS Synergies initiative (formerly known as Grand Challenges), briefly discussed above. This initiative aims to facilitate and incentivize the integration of *existing* projects funded under different NPs. The initiative targets opportunities for coordination across projects with the potential to yield benefits great enough to justify the transaction costs of a complex multi-program project while not compromising the achievement of individual project plan objectives.[24]

The ARS Synergies initiative does not directly offer resources to address the additional work entailed by a multi-program project. However, research teams that receive approval to pursue a ARS Synergies project get preferential access to post-docs available through a competitive internal ARS program. A shared post-doc can not only provide assistance in carrying out the project, but is incentivized to make the project work. The use of such a mechanism to align incentives across participants is in keeping with good practice.

The ARS Synergies initiative does not address the transaction costs of coordinating across projects. One important way to do this is to provide some funding for travel especially in the case of research teams with participants in different locations that have not worked together before. Funding to support travel and focused collaborative activities can help reduce transaction costs over the life of the project by helping build trust and mutual understanding.

The above gap analysis of the Synergies initiative offers a concrete illustration of the importance of strategic investments in travel to enable the building of scientific teams across programs and locations. However, the same logic could be applied to any ARS effort to enable cross-program, cross-location research.

Recommendation 3.8: *Provide competitive funding for travel to support the building of scientific teams seeking to undertake cross-program, cross-location projects.*

Opportunities to Support High-Risk/High-Return Research

In this section, we discuss two approaches to promoting high-risk/high-return (HR/HR) research.

1. Change the standard R&D management processes to encourage everyone to undertake high-risk/high-return research.

[24] U.S. Agricultural Research Service. 2017. "Agriculture Faces a Crisis: The Grand Challenge for the USDA Agricultural Research Service." Beltsville, Maryland. [ARS internal document].

2. Create special programs focused on eliciting the efforts of risk-takers.

These two approaches are complementary; and they are not mutually exclusive. Both are needed to promote innovative research.

The first approach has the potential to encourage more innovative, riskier research on the margins, but is constrained by the fact that standard R&D management processes must serve multiple objectives, including helping to ensure basic quality and feasibility of proposals by all scientists.

The second approach focuses on creating opportunities to elicit the talent and energies of risk-takers/creative scientists. This approach, which is exceptional, is better suited to enabling high-risk/high-return research.

Approach #1: Change Standard R&D Management Processes to Encourage Scientists Generally to Undertake HR/HR Research

As part of its assessment of opportunities under the first approach, the Academy study team focused its research on two standard R&D management processes at ARS: (1) prospective peer review of projects; and (2) scientist performance review processes. Both were identified in our initial research as potentially discouraging more innovative, riskier research.

1. Prospective peer review of research projects

In assessing the prospective peer review process as a potential impediment to more innovative, riskier research, it is important to understand how this process works at ARS. Unlike prospective peer review at extramural research organizations, prospective peer review at ARS is not used to identify and prioritize the best proposals for funding. ARS projects to be reviewed are already funded. Peer review is intended to fine tune and strengthen project plans.

Given this understanding of the role of prospective peer review at ARS, it is not clear in principle how this process inhibits more innovative, riskier research. Interviews with ARS scientists and staff did not provide additional insight. Interviewees disagreed on whether and to what extent the prospective peer review process discouraged more innovative, riskier research projects.

While traditional approaches to prospective peer review are generally recognized in the good practice literature as a conservative influence on research, it is important to note that

this literature applies to extramural organizations.[25] Still is it worth considering good practice alternatives presented in the literature. These include:

- Reviews weighted to favor the potential impact of research over risk of failure;
- Double-blind reviews (i.e., don't include information on the proposer and track record) to mitigate the bias in favor of past success;[26] and
- Complement in-person reviews with mail-in reviews to counter the conservative, consensus-based dynamics of in-person reviews.[27]

2. Scientist performance review systems

ARS scientists are evaluated both annually and every three to seven years. Scientists are evaluated each year by their line supervisor. These annual reviews, which inform decisions on step increases in salary, largely focus on the quantifiable output of researchers, and are based principally on the number of publications a researcher produced in a given year. Another important objective of the annual review is to ensure a floor for performance. For a non-lead, non-supervisory scientist, the minimum publications requirement is authorship on two publications in refereed journals with authorship at any level.

Interviews with ARS scientists and staff yielded disagreement about whether and to what extent scientist performance systems discourage high-risk/high-return research. Other research by the study team into the specifics of ARS scientist performance systems did not yield further insight into the issue.

<u>Approach #2: Create Special Programs Focuses on Eliciting the Efforts of Risk-Takers</u>
Innovation challenges/inducement prizes offer an example of this second approach. Innovation challenges/inducement prizes are designed to induce innovative research by inspiring and focusing research efforts. They vary in scope and ambition. They may have a narrow, technical focus or a broader, transformational focus on developing new sociotechnical systems, which is typical of X-Prize type challenges originated by the DARPA.

[25] A consensus statement on this issue is provided in National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. 2007. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Washington, DC: The National Academies Press. https://doi.org/10.17226/11463.
[26] Evidence of bias in single-blind reviews is presented in: Tomkins, Andrew, Min Zhang, and William D Heavlin. 2017. "Reviewer Bias in Single- Versus Double-Blind Peer Review." *Proceedings of the National Academy of Sciences* (National Academies Press) 114 (48): 12708-12713. https://www.pnas.org/content/114/48/12708.long.
[27] In the case of ARS, all reviews are submitted via email. (Email communication from Marquea King, Director, Office of Scientific Quality Review, May 19, 2020)

In all cases, a key aspect of challenges is to broaden participation and thereby bring new perspective and capabilities to bear on them.

Innovation challenges/inducement prizes programs generally aim to tap ideas and expertise external to the agency. However, the innovation challenge/inducement prize approach has been applied to internal scientific workforces in some cases. EPA has a long-standing program.[28]

The ARSX is an internally-focused X-Prize type challenge. The design of ARSX is in keeping with best practice in most ways, including: (1) a request for proposals that minimizes requirements; (2) double-blind review of proposals focusing on potential impact; (3) a process for working with first-round winners to strengthen their proposals; and (4) fail-fast design of project plans.[29] What is missing, based on the study team's review of experience at DARPA and EPA, is a staged process for progressively reducing the risk of the research until it can be transitioned for further development through the normal research management process. This reflects, in part, the lack of a regular source of funding ARSX. Like other ARS initiatives, it is funded with money temporarily available due to extraordinary circumstances such as the recent hiring freeze. (Discussion of good practice and recommendations regarding funding for such investments is discussed in Chapter 4.)

Recommendation 3.9: *Augment the design of the ARSX initiative to include a multi-stage process that allows for progressively reducing the risks associated with ARSX projects to the point that further development can be handled through the standard research management processes.*

Currently, the incentive structure of the normal R&D management system is not integrated with ARSX. There is no provision in the Agency's performance evaluation system for crediting ARS scientists for participation in ARSX. This may inhibit fuller participation and participation over time if it is perceived that risk-taking is not rewarded within ARS, or that failure is penalized. Although ARS scientists interviewed disagree about the importance of the scientist performance evaluation system as an impediment to more innovative, riskier research, they do agree that it was an impediment. The addition of a formal provision for crediting participation in HR/HR initiatives, like ARSX, could stimulate participation by indicating a commitment by ARS leadership to support risk-taking.

[28] The Pathfinder Innovation Projects program has been operating since 2011. Current information on the program may be found at https://www.epa.gov/innovation/pathfinder-innovation-projects.

[29] This practice involves designing research in a way to test key assumptions related to success and in order to quickly address risks. The approach seeks to support more innovative research by mitigating risk as early as possible.

Recommendation 3.10**:** *Add a provision to the administration of the scientist performance evaluation system that credits participation in high-risk/high-return research initiatives, such as ARSX.*

Risk-taking and the failures it necessarily entails are potentially difficult for any early-career scientist. A program for mentoring such scientists could help cultivate risk-taking by providing them with advice and support from more experienced, successful scientists who have learned how to better navigate the pitfalls and reap the benefits of undertaking more innovative, riskier research. A key consideration in the design of a mentoring program is to provide flexibility to mentees in the choice of mentors and in setting goals for the relationship. This helps ensure a good fit, which is essential to success.[30] Mentoring Matters, a mentoring program at NASA's Goddard Space Flight Center, offers an example of a program organized on this principle.[31] Another example of mentorship exists at Massachusetts Institute of Technology for junior faculty.[32]

Recommendation 3.11: *Create a mentoring program for early-career ARS scientists interested in pursuing high-risk/high-return research. This program would enable scientists to choose mentors from a group of successful scientists and fashion relationships that fit their particular needs.*

Building Enterprise-level R&D Capabilities

ARS has several ongoing initiatives attempting to build enterprise-level R&D capabilities. These initiatives are attempting to aggregate, leverage, and analyze data across the enterprise; and build and provide innovative tools to the enterprise. These initiatives include Partnerships for Data Innovations, Breeding Insights, AI Center of Excellence, and efforts to improve ARS' high-performance computing capabilities.

Barriers to building enterprise capabilities at ARS

Efforts to build enterprise-level capabilities have been constrained by the characteristics of how ARS research is funded and organized, discussed earlier:

[30] For a discussion of mentor matching and goodness of fit, see: Bozeman, Barry, and Mark K Feeney. 2008. "Mentor Matching: A "Goodness of Fit" Model." *Administration & Society* (Sage Journals) 40 (5): 465-482. https://doi.org/10.1177%2F0095399708320184.

[31] For a brief discussion of Mentoring Matters, see: https://www.td.org/insights/mentoring-matters-at-nasa. (accessed May 29, 2020)

[32] For a brief description, see: https://web.mit.edu/physics/policies/dept/jrfac.html.

1. Investments in capabilities enabling research generally are made in the context of developing projects to meet the needs of particular stakeholder groups, which are then rolled up into individual National Programs; and
2. Resource allocation and accountability track with individual National Programs.

This report has four recommendations to improve the organizational dimension of building enterprise-level capabilities (recommendations addressing the challenge of funding enterprise-level investments is addressed in Chapter 4). These recommendations are intended to enable and take a more integrated, enterprise-wide approach.

Recommendation 3.12: *Strengthen efforts to build enterprise capabilities.*

This first recommendation, 3.12, offers a range of options for strengthening the capacity of ARS to plan and execute efforts to promote innovative research. These options draw on good practice at other well-regarded research agencies in the U.S. and abroad. They are presented in terms of how much change this would entail in the ARS research organization, from low to high, based on the study team's determination of how difficult they would be to achieve given ARS' organizational culture and stakeholder environment. These options are not intended to stand alone, but represent building blocks in developing the capacity to manage the research enterprise in a more integrated, strategic way.

- **Option 1 (low-change)** – Develop a systematic process for identifying, prioritizing and potentially budgeting enterprise-level requirements for enabling capabilities, such as data analytics.

  NOAA offers a model for an enterprise-level, requirements-based process for building an R&D strategic plan. At NOAA, budget estimates for R&D investments in enterprise capability building result from an integrated requirements-based approach strategic planning process by the six line offices. This results in a budget line-item for "Innovative Research and Technology," which in FY19 resulted in $13.1 million appropriation and 11 FTE.

- **Option 2 (medium-change)** – Establish an office with clear authority to coordinate and implement investments in enterprise-level capabilities.

  At NIH, Office of Research Infrastructure Programs (ORIP) plays a major role in coordinating and managing programs contributing to research infrastructure within and across NIH, and its many institutes and centers. The office performs four main functions: (1) developing a 5-year strategic plan for developing and sharing research infrastructure across the enterprise, which complements Agency-wide strategic plan;

(2) awards grants to support research resources; (3) plans, organizes, and conducts workshops to identify and pursue new opportunities across the enterprise; and (4) supports research-training opportunities. The FY19 President's Budget provided ORIP $252 million.

- **Option 3 (high-change)** – Establish an office with clear authority to coordinate and implement investments in enterprise-level capabilities together with the creation of a dedicated pool of discretionary funding for such investments (Academy recommendations to build support for funding are discussed in Chapter 4.)

The following three recommendations, 3.13, 3.14, and 3.15, address opportunities to enhance enterprise capabilities within the workforce.

Enterprise-Level Approach to Talent Management

The ability to hire and retain the appropriate technical skillsets at an enterprise-level is a key consideration for ARS when implementing R&D capabilities. ARS has typically hired employees with engineering and data analytics capabilities in response to new projects at specific locations or into specific positions within NPs. The current hiring surge at ARS provides an opportunity to pilot an enterprise approach to hiring and talent management.[33] ARS should take advantage of its current hiring surge to pilot the hiring of positions that are clearly oriented toward meeting enterprise needs, instead of positions tied to individual locations.

Recommendation 3.13: *Take advantage of current hiring surge to pilot an enterprise approach to hiring and talent management.*

The lifting of the hiring freeze in 2020 and the large number of retirements expected in the near future present another opportunity to promote innovative research. Academic literature offers strong evidence that diversity can promote innovation and scientific creativity. Moreover, talent drawn from other demographics may be more available to government.[34] This suggests that ARS might benefit significantly from targeting a more diverse demographic in its recruitment efforts.

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[33] ARS has recently had its hiring freeze lifted and, as of May 2020, is hiring for a number of open positions.; Kettl, Donald, Joel Aberbach, Joshua Gotbaum, Doris Hausser, and Sean O'Keefe. 2018. *No Time to Wait, Part 2: Building a Public Service for the 21st Century.* Washington, DC: The National Academy of Public Administration. https://www.napawash.org/uploads/Academy_Studies/NTTW2_09192018_WebVersion.pdf.

[34] D. A. (2020). The Diversity–Innovation Paradox in Science. *Proceedings of the National Academy of Sciences*, *117*(17), 9284-9291. The latter article finds that doctoral students are more likely to make novel contributions, see Xie, L., Zhou, J., Zong, Q., & Lu, Q. (2020). Gender diversity in R&D teams and innovation

Recommendation 3.14: *Take advantage of the end of the USDA hiring freeze and the higher number of retirements expected in the near future to increase the diversity of the ARS scientific workforce through recruitment of a broader demographic.*

Another important consideration in hiring scientific and technical staff in a rapidly changing research environment is the need to be responsive while retaining flexibility to change direction. In the past, ARS has focused on hiring FTEs. The downside of hiring permanent employees in response to new demands is that demands change while FTEs remain and may not always be able to adapt to new circumstances. An uncertain research environment places a premium on flexibility. This suggests that ARS would benefit from taking greater advantage of its authority to hire scientific and technical staff on a temporary basis.

Recommendation 3.15*: Take greater advantage of term appointments in order to be responsive to new research developments while retaining flexibility to change direction as needed in a rapidly changing research environment.*

efficiency: Role of the innovation context. *Research Policy*, *49*(1), 103885; Hofstra, B., Kulkarni, V. V., Galvez, S. M. N., He, B., Jurafsky, D., & McFarland. The second article finds that doctoral students from under-represented groups are more likely to make novel scientific contributions, but that these contributions are often devalued and discounted. For example, these contributions are less likely to be taken up by other scholars and less likely to result in successful scientific careers than for majority groups. This suggests an opportunity for recruiting talent.

Chapter 4 – Building Support for Strategic Research Investments

This chapter contains two recommendations on building support for strategic research investments and enhancing the flexibility of ARS to strategically invest at an enterprise-level. The first recommendation explores a new funding opportunity for ARS and provides good practice examples from other federal agencies. The second recommendation addresses an existing flexible congressional funding practice, and recommends an approach to optimizing that practice.

The study team's analysis of ARS funding is multi-faceted, with examination of:

- The ARS funding model and patterns;
- Funding models and patterns at other federal agencies; and
- Information collected from interviews with NP staff, regions, field scientists, and senior executives at other federal R&D programs, including EPA, NIH, the National Oceanic and Atmospheric Administration (NOAA), and NASA.

In addition to this analysis, the report leverages external subject matter expertise, including EAG members' individual experience, to identify opportunities to broaden flexible distribution of ARS research funding.

Opportunities to Enhance ARS' Flexibility to Make Strategic Research Investments

As discussed in Chapter 2, the following three characteristics of ARS' funding structure can limit flexible funding options: (1) research funding that is tied to the needs of particular stakeholder groups and locations; (2) research funding that is allocated by National Program; and (3) scientists that are base-funded.[35] This funding structure can limit ARS' capacity for strategic investments at an enterprise-level. The study team identifies several ways by which ARS' capacity can be narrowly focused and thus mission effectiveness can be negatively impacted:

- **Cross-Program Research**: ARS staff members perceive that cross-program research is limited by: the inability to share funds across National Programs; the staggered 5-year National Program Cycle; and lack of funding to support cross-program opportunities embodied in projects proposed under the Synergies program.
- **High-Risk, High-Return Research**: One factor that inhibits HR/HR research at ARS is a lack of dedicated funding for it. ARS started the ARSX initiative because the normal

[35] By "base-funding", the study team means: When an organization has scientists whose salaries and research are funded by annual appropriations, and thus do not need to compete for external sources of funding, like in an extramural research program.

program cycle can inhibit HR/HR research, Presently, the ARSX initiative has cobbled together one year of funding from the Office of Technology Transfer's (OTT) Innovation Fund.

- **Innovative Enterprise Capabilities**: Because ARS lacks a dedicated office and budget line-item for building enterprise research capabilities, the Agency, at times, struggles to systematically build the capabilities that are increasingly important in today's rapidly evolving research environment. This can lead to inefficiencies and, more importantly, missed opportunities to tap synergies across projects and programs at ARS.

Several recommendations in Chapter 3 address structural and programmatic opportunities to address two challenges facing ARS: (1) undertaking innovative and cross-cutting research; and (2) building enterprise-level capabilities to enable more a more efficient and innovative research enterprise. The final component of enhancing this capacity is building support for the discretionary, enterprise-level funding needed to support strategic research investments.

With regard to the first challenge, the Academy offers two recommendations. The first recommendation (4.1) addresses the issue directly by seeking the creation of a dedicated pool of funds to be awarded competitively at the enterprise level for this purpose. The second recommendation (4.2) calls for ARS to take a more systematic approach to using 0500 accounts in order to take greater advantage of an existing congressional funding practice. The study team also offers a recommendation (4.3) to address the challenge of funding the development of enterprise-level capabilities.

Recommendation 4.1: *Develop a strategy to build USDA, Office of Management and Budget, and congressional support for dedicated pools of competitive funding to enable high-risk/high-return and cross-cutting research.*

As discussed in greater detail in Chapter 3, ARS has been attempting to foster more HR/HR and cross-cutting projects through efforts like ARSX and Synergies. However, these efforts have been hindered by the lack of dedicated funding.

A dedicated pool of competitive funding is one method for federal government R&D agencies to support HR/HR and cross-cutting research projects. There is both domestic and international precedent for dedicated, headquarters-level discretionary pools of competitive funding for both extramural and intramural research projects. The National Institutes of Health provide the most pertinent domestic precedent. We also discuss precedents offered by Agriculture and Agri-Food Canada and Brazil's EMBRAPA.

National Institutes of Health (NIH)

- **NIH's use of extramural and intramural dedicated pools of competitive funds.** The National Institutes of Health has two different dedicated pools of discretionary funding.
    - **NIH Common Fund (Extramural):** The NIH Common Fund, established by the 2006 NIH Reform Act, funds several extramural programs that seek to facilitate high-risk, high-return research and cross-cutting (trans-NIH) research.[36] NIH seeks to use the Common Fund as a "venture capital" space where high-risk, innovative endeavors with the potential for extraordinary impact can be supported. Common fund programs are short-term, goal-driven strategic investments.[37]

      The Common Fund is managed by the Office of Strategic Coordination (OSC), which is within the Office of the NIH Director. The OSC ensures that the Common Fund is used to fund enterprise-wide challenges and priorities, allowing NIH to plan and execute strategically. An important aspect of the Common Fund is that it focuses on challenges that can hypothetically be solved in 5-10 years. Establishing that end-point up front, is an important step to ensuring the research problem is defined correctly.
    - **Director's Innovation Fund (Intramural)**: The Director's Innovation Fund (Innovation Fund) is a pot of money at the discretion of the NIH Director for funding intramural research, and is separate from the Common Fund. The Innovation Fund receives a $1.5 million appropriation from Congress, annually. In addition, institutes and research centers contribute 1 percent of their intramural research budget to the Innovation Fund.

      The creation of this intramural fund was encouraged by a 2014 review of the NIH's intramural research program, which recommended that NIH bolster support for highly innovative research.[38] Specifically, the review recommended that NIH establish a trans-NIH innovation fund for intramural research and encourage the formation of optional institute and center innovation funds.[39]

[36] National Institutes of Health. 2016. *NIH Reauthorization.* April 4. Accessed May 12, 2020. https://www.nih.gov/about-nih/who-we-are/nih-reauthorization.
[37] Ibid
[38] National Institutes of Health. 2014. "Long-Term Intramural Research Program (LT-IRP) Planning Working Group Report." Washington, DC.
[39] Of NIH's 27 institutes and centers, 23 have intramural programs. These congressionally-mandated programs vary in budget (5-20 percent, about $4 billion).

NIH's intramural research primarily focuses on HR/HR research that would not otherwise be conducted by industry or through extramural means. The intramural Innovation Fund seeks to facilitate even greater levels of innovative research by providing an additional resource set within the intramural program.

Precedents from Canada and Brazil

Canada and Brazil set aside a proportion of government appropriations for intramural research for competitive funding of enterprise-level investments in research. Both the Canadian and Brazilian agricultural research organizations, Agriculture and Agri-Food Canada and EMBRAPA, set aside roughly 60 percent of legislatively appropriated funding for competitively awarded internal research.[40]

Recommendation 4.2: *Take a more systematic approach to seeking and shaping potential 0500 account funding from Congress to use for strategic investment opportunities.*

For some projects and monies appropriated by Congress, ARS uses headquarters-controlled accounts, called 0500 accounts, to manage and disburse the funding (ARS currently maintains 28 different 0500 accounts). Congress does not specifically designate funding for 0500 accounts.

The purpose of 0500 accounts is to disburse funding to support specific areas of research. 0500 accounts are held and managed at the headquarter-level. This funding is often used for cooperative agreements and is often awarded on a competitive basis, determined by the review panel, at different intervals throughout the year. 0500 funding for the new initiatives funded on a competitive basis can eventually be subsumed by the permanent Agency budget, if the initiatives prove viable. In other words, 0500 accounts can be converted into ARS' normal annual appropriation over time.

The formats for disbursement vary between 0500 accounts, depending on the stakeholders involved. Some 0500 accounts use requests for proposals (RFPs). In these cases, once proposals are selected for award, funding levels are determined by NPLs, in consultation with ARS stakeholders. For other 0500 accounts, requests for applications are used, and NPLs involve stakeholders in the review process.

[40] One key difference between these organizations and ARS is the division in appropriations between research project expenses and capital/operating expenses. Both Canada and EMPRAPA have separate budget lines for the two expenses. However, ARS does not have separate budget liens, which could potentially limit the use of competitive funding techniques.

ARS' use of 0500 funds for engaging with the U.S. Wheat and Barley Scab Initiative (USWBSI) is one example of how the Agency supports research on significant challenges in agriculture. Fusarium head blight, or scab, is a fungal disease that can occur on all small-grain crops grown in North Dakota.[41] One of the Agency's 0500 accounts partially funds the USWBSI service centers. As a result, ARS has produced a number of resources and tools that help stakeholders mitigate the detrimental effects of the disease through the USWBSI. In this way, USWBSI represents a collaborative effort between ARS scientists, and land grant universities. It is run by an executive committee, co-chaired by a researcher and stakeholder grower. The executive committee administers the 0500 grant program.

Based on its research on 0500 accounts, the Academy study team identified potential strengths, weaknesses, opportunities, and effective practices. Based on this assessment, the Academy recommends that ARS should:

- Identify good practices for the use of 0500 accounts, which include:
    - Competitive funding;
    - Make funds available to ARS and outside researchers; and
    - Gather and use input from ARS' research organization in the administration of accounts to help ensure mission focus and integration of research efforts.
- Assess the benefits and challenges of different 0500 accounts
    - **Potential benefits.** 0500 accounts provide scientists the opportunity to be nimbler to more quickly respond to emergent agricultural challenges. In addition, 0500 accounts can encourage scientists to explore HR/HR ideas.
    - **Potential challenges**. 0500 accounts can be vulnerable to budget cuts because they are not tied to ARS employees' salaries. ARS staff members suggest that an inconsistent process for competing for funds in these accounts can create challenges and uncertainty for scientists.
    - **Potential opportunities**. 0500 accounts provide opportunities to organize stakeholders around agricultural challenges that span across commodity groups, allowing ARS to build support for cross-cutting, cross-location research projects. There is also greater opportunity to identify connections between various 0500 initiatives, making it easier to identify potential stakeholder networks.
- Determine research domains that would benefit from 0500 accounts
- Target outreach to relevant external stakeholders in support of flexible research funding

[41] U.S. Wheat and Barley Scab Initiative. n.d. Accessed May 1, 2020. https://scabusa.org/about.

Recommendation 4.3: *Develop a strategy to build USDA, Office of Management and Budget, and congressional support for a dedicated pool of funding for investment in enterprise-level capabilities.*

As discussed earlier in the report, it is critical for ARS to be able to invest in capabilities (e.g., AI, data analytics) that enable and leverage research across the enterprise. While such investments might well incorporate a competitive aspect, the main purpose is to build capabilities available across the enterprise rather than tap talent wherever it might be in the organization to carry out cross-cutting or high-risk/high-return research.

NOAA offers an important precedent for funding such investments. NOAA enjoys base-funding for its Innovative Research and Technology Program, which supports improvements in environmental modeling of capabilities to upgrade the accuracy of NOAA's short-term weather warnings, seasonal forecasts, hurricane forecasts and global climate and weather predictions. This includes support for high performance computing.[42]

[42] National Oceanic and Atmospheric Administration. 2019. *Congressional Budget Justification for Fiscal Year 2020.* Silver Spring: United States Department of Commerce, OAR-115. https://www.noaa.gov/sites/default/files/atoms/files/NOAA-FY20-Congressional-Justification.pdf.

Appendix A – Expert Advisory Group and Study Team Biographies

Expert Advisory Group Members

Sandra Archibald; Dean and Professor, Evans School of Public Affairs, University of Washington. Former positions with Humphrey Institute of Public Affairs, University of Minnesota: Deputy Associate Dean; Interim Dean; Associate Dean for Academic Affairs and Research Programs; Associate Vice Provost for Faculty Development; Professor; Associate Professor; Adjunct Associate Professor; Associate Dean and Director of Graduate Studies. Former Assistant Professor of Applied Economics, Food Research Institute, Stanford University.

Barry Bozeman; Arizona Centennial Professor of Technology Policy and Public Management; Director, Center of Organizational Research and Design, Arizona State University. Former Ander Crenshaw Chair, Department of Public Administration and Policy, University of Georgia; Regents' Professor of Public Policy, School of Public Policy and Director, Research Value Mapping Research Program, Georgia Institute of Technology; Director, Center for Technology and Information Policy, Maxwell School of Citizenship and Public Affairs and L.C. Smith College of Engineering, Syracuse University; Director, Doctoral Program in Public Administration, Maxwell School of Citizenship and Public Affairs, Syracuse University.

Mamie Parker; Founder and President, Ma Parker and Associates. Former positions with U.S. Fish and Wildlife Service: Head of Fisheries and Assistant Director, Headquarters, Northeast Regional Director; Chief of Staff , Headquarters, Deputy Geographic Assistant, Regional Director Atlanta, Georgia, Regional Environmental and Ecosystem Coordinator Minneapolis; Fish and Wildlife Biologist, Columbia, Missouri; Fishery Biologist, Lake Mills and Madison, Wisconsin; Fish and Wildlife Biologist, Green Bay, Wisconsin; Fishery Biologist Trainee, New London, Minnesota; Fishery Biologist Trainee, La Crosse, Wisconsin.

Academy Study Team

Brenna Isman, *Director of Academy Studies.* Ms. Isman accepted her initial appointment with the Academy in 2008. She currently provides oversight for all Academy's studies. Ms. Isman recently served as the Project Director for the Academy's project that assisted a financial oversight board in developing and implementing its strategic plan. She also directed the Academy's statutorily required assessments of the National Aeronautics and Space Administration's use of its Advisory Council and the Environmental Protection Agency's practices for determining the affordability of regulatory mandates, as well as the Academy's organizational study of the U.S. State Department's Office of Inspector General. Her prior consulting experience includes both public and private sector clients in the areas of communication strategy, performance management, and organizational development. Prior to joining the Academy, Ms. Isman was a Senior Consultant for the Ambit Group and a Consultant with Mercer Human Resource Consulting facilitating effective organizational change and process improvement. Ms. Isman holds a Masters of Business Administration

(MBA) from American University and a Bachelor of Science (BS) in Human Resource Management from the University of Delaware.

Roger Kodat, *Senior Project Director.* Mr. Kodat has led more than 30 projects for the Academy. He brings twenty years of commercial and investment banking experience with JPMorgan Chase, and six years of senior level federal government experience at the Department of the Treasury. Appointed by President George W. Bush in 2001 to serve as Deputy Assistant Secretary of Treasury, he was responsible for Federal Financial Policy. Some of his tasks at Treasury included policy formulation for the 2006 Postal Accountability and Enhancement Act; rule making and oversight of Federal loan and loan guarantee programs; and management of the Federal Financing Bank (a $32 billion bank at that time). Mr. Kodat holds a BS in Education from Northwestern University and both an MBA in Finance and Masters of Arts (MA) in Political Science from Indiana University.

Jonathan Tucker, *Senior Analyst.* Dr. Tucker is a senior analyst and project director at the Academy. His areas of expertise include strategic planning/foresight, organizational design, change management, and S&T/innovation policy. His public management consulting experience includes projects with more than twenty federal agencies. Recent projects include assessment of research coordination function at the U.S. Department of Transportation; developing a strategic plan for the Office of Urban Indian Health Programs (U.S. Indian Health Service); developing options for the establishment of a new Under Secretary at USDA focused on international trade; developing a white paper for the Project Management Institute on institutionalizing project and program management in the federal government; assessing Census transformation initiatives; developing a long-term strategic plan for operational transformation at the Social Security Administration. In addition to his consulting activities, Jon contributes to the work of the Academy's Strategic Foresight Panel (part of the broader Academy Transition 2016 initiative). Dr. Tucker also has experience assessing science and technology policies and programs, with a focus on supporting innovation. He has worked for organizations including Battelle; the National Research Council; the National Institute of Standards and Technology; and the New York State Department of Economic Development. He holds a Ph.D. in Public Policy (with a concentration in Science and Technology Policy) from George Mason University, an MS in Science and Technology Studies from Rensselaer Polytechnic Institute, and a Bachelor of Arts (BA) from New College of Florida.

Sharon Yoo, *Research Analyst*. Ms. Yoo provides research and analytical support to several Academy initiatives and draws on her international development, education, and technology policy expertise. She has extensive research experience and has published in these topics. She previously worked with organizations such the UNDP, MIT Media Laboratory, and several technology start-ups. Her previous research includes Pakistan's energy crisis, North Korea's tuberculosis outbreak, and unique applications of artificial intelligence. She is proficient in Korean, Hindi/Urdu, and English. She holds a dual degree masters from The Johns Hopkins University School of Advanced International Studies and Harvard Graduate School of Education.

Elijah Evans, *Research Analyst.* Mr. Evans joined the Academy in February 2017. His public management consulting experience includes projects with more than ten government agencies. His most recent projects include an assessment of the National Park Service construction program, an assessment of strategies for enhancing the technology policy resources available to the U.S. Congress, and two strategic planning and employee engagement projects for federal oversight agencies. Mr. Evans received a BS in Convergence Journalism and Political Science from Abilene Christian University in December 2016.

Kyle Romano, *Senior Research Associate.* Mr. Romano has provided research support for several Academy studies. Most recently, he has served on Academy projects assessing the alignment of the Federal Bureau of Prisons with its healthcare mission, and the U.S. Forest Service's research and development enterprise. He graduated from the Indiana University School of Public and Environmental Affairs where he earned a Master of Public Affairs.

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Appendix B – Selected Bibliography

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Appendix C – List of Interviews

(Titles and positions listed are accurate as of the time of the Academy's initial contact)

Agricultural Research Service

Administrator's Immediate Office

Drumm, Sharon – Chief of Staff

Mayo, Gary – Legislative Affairs Officer

Pearl, Stephanie – Science Communications Advisor

Office of National Programs

Beebout, Sarah – National Program Leader

Bretting, Peter – National Program Leader

Buser, Michael – National Program Leader

Coleman, Loren – Program Analyst

Cook, Kimberly L. – National Program Leader

Costa, Jose – National Program Leader

Buckley, Ellen P. – Program Analyst

Douglas G. Luster – Acting Deputy Administrator

Eve, Marlen – Deputy Administrator

Finley, John – National Program Leader

Gay, Cyril – Senior National Program Leader

Hackett, Kevin – National Program Leader

Hanes, Glenn – Program Specialist

Kappes, Steven – Associate Administrator

Kessler, Nadine M. – Program Analyst

Klemens, Jennifer – Program Analyst

Klurfeld, David M. – National Program Leader

Knaebel, David – National Program Leader

Kozlovac, Joseph – Biological Safety Specialist

Lester, Gene E. – National Program Leader

Lindsay, James A. – National Program Leader

Okamuro, Jack – National Program Leader

Peters, Deb – Acting Chief Science Information Officer

Rexroad, Caird, III – National Program Leader

Rinehart, Tim – National Program Leader

Roberts, Sharon – Program Analyst

Scott, Roy – National Program Leader

Silverstein, Jeffrey – Deputy Administrator

Starke-Reed, Pam – Deputy Administrator

Tsegaye, Teferi – National Program Leader

Vadas, Peter – National Program Leader

Vallet, Jeffrey – National Program Leader

Widmer, Tim – National Program Leader

Budget and Program Management Staff

Arnold, Michael – Director

Stetka, Jill – Staff Officer

Office of International Research Programs

Bhotika, Smriti – International Affairs Specialist

Moore, Ryan – International Affairs Specialist

Norrington, Bryan – Director, Office of International Research Programs

Shekailo, John – International Affairs Specialist

Watson, Ingrid – Deputy Director

Witting, Marcella – International Affairs Specialist

Wran, Tanya – Management and Program Analyst

Varella, Alexandre Costa – Coordinator to Labex EUA, Embrapa

Office of Scientific Quality Review

King, Marquea – Director and Program Coordinator

Office of Technology Transfer

Bahar, Mojdeh – Assistant Administrator, Office of Technology Transfer

Field

Ashworth, Amanda – Soil Scientist, Poultry Production

Atland, James – Research Leader

Baik, Byung-Kee – Acting Research Leader

Bhatnagar, Deepak – Center Director, Southern Regional Research Center

Chandler, Laurence – Area Director, Plains Area Office

Crouch, Jo Anne – Research Molecular Biologist, Mycology and Nematology

Duke, Steven – Research Leader, Natural Products Utilization Research Unit

Gowda, Prasanna – Associate Director, Office of the Area Director, Plains Area Office

Lillehoj, Hyun – Research Molecular Biologist

Marshall, David – Research Leader, Plant Science Research

Matteri, Robert L. – Area Director, Pacific West Area

McHugh, Tara – Western Regional Center Director

Naranjo, Steve – Center Director, Arid-Land Agricultural Research Center

Pentoja, Albert – Associate Area Director, Midwest Area

Swietlik, Dariusz – Area Director, Northeast Area

Tucker, Archie – Area Director, Southeast Area

Van Tassel, Curt – Research Geneticist, Animals Genomics and Improvement Lab

Federal Government Agencies

Angle, Scott – Director, National Institute of Food and Agriculture

Bahadori, Tina – Director, National Center for Environmental Assessment, EPA

Benforado, Jay – Chief Innovation Officer, EPA

Doremus, Paul – Chief Operating Officer, Fisheries, National Oceanic and Atmospheric Administration

Esteban, Emilio – Chief Scientist, Food Safety and Inspection Service (FSIS)

Gottesman, Michael – Deputy Director for Intramural Research, NIH

Gupta, Shobhana – Open Innovation and Community Applications Manager, NASA

Lalli, Donna – Science Adviser, Animal and Plant Health Inspection Service (APHIS)

Meador, Jarah – Director, Open Innovation Programs, GSA

Prabhakar, Arati – Former Director, DARPA

Rader, Steven – Deputy Manager, Center of Excellence for Collaborative Innovation, NASA

Sheth, Kartik – Deputy Program Scientist, Astrophysics Division, NASA

Smith, Jonathan – Director, Resource Inventory Branch, Natural Resources Conservation Service (NRCS)

Teague, Kristopher – Deputy Director, VHA Innovation Ecosystem

Wilder, Elizabeth – Director, Office of Strategic Coordination, NIH

Other Experts

Thomson, Allison – Vice President, Science & Research, Field to Market Sustainability Alliance

LaVigne, Andrew – President and Chief Executive Officer, American Seed Trade Association

Bubeck, David – Research Director, Corteva

Brown, Donnell – President, National Grape Research Alliance

Knipling, Edward – Former Administrator, ARS

Campbell, Ian – Director, Science Coordination Division, Canada Department of Agriculture and Agri-Food

Eelman, Jake – Acting Director, Science Policy and Partnerships Division, Canada Department of Agriculture and Agri-Food

Mayne, James – Vice President, Science Advocacy, PhARMA

Jones, Jennifer – Director of Supply Programs, United Soybean Board

Simmons, Kathy – Chief Veterinarian, National Cattlemen's Beef Association

Cornish, Katrina – Chief Science and Technology Officer, EnergyEne Inc.

Eversole, Kellye – President, Eversole Associates

Wollenberg, Lini – Flagship Leader for Low Emissions Development, CGIAR

Wagstrom, Liz – Chief Veterinarian, National Pork Producers Council

Kumar, Mahesh – Senior Vice President, Global Biologics Research, Zoetis

Perham, Michael – Director, Innovations and External Relations, Janelia Research Campus

Matt, Mireille – Director of Research, Institut National De La Recherche Agronomique

Dokoozlian, Nick – Vice President of Viticulture, Chemistry and Enology, E&J Gallo Winery

Dunkle, Ric – Senior Director, Seed Health and Trade, American Seed Trade Association

Schoen, Robin – Director, Board Agriculture and Natural Resources, National Academies of Sciences, Engineering, and Medicine

Rockey, Sally – Executive Director, Foundation for Food and Agriculture Research

Parsa, Soroush – Lead Innovation Scientist, Consultative Group on International Agriculture Research; Former ARS AAAS Fellow

Honeycutt, Wayne – Chief Executive Officer, Soil Health Institute

Appendix D – National Program Cycle

ARS plans and reviews its research activities on a 5-Year National Program Cycle. Each program's cycle is conducted on a staggered basis, with groups of National Programs beginning and completing their cycle at different times. The cycle includes the following 5 steps:

1. Develop 5-year National Program Action Plans
2. Develop Program Direction and Resource Allocation Memos (PDRAMs)
3. Develop project plans for prospective peer review
4. Conduct prospective peer review of approved projects
5. Conduct retrospective assessments of National Programs

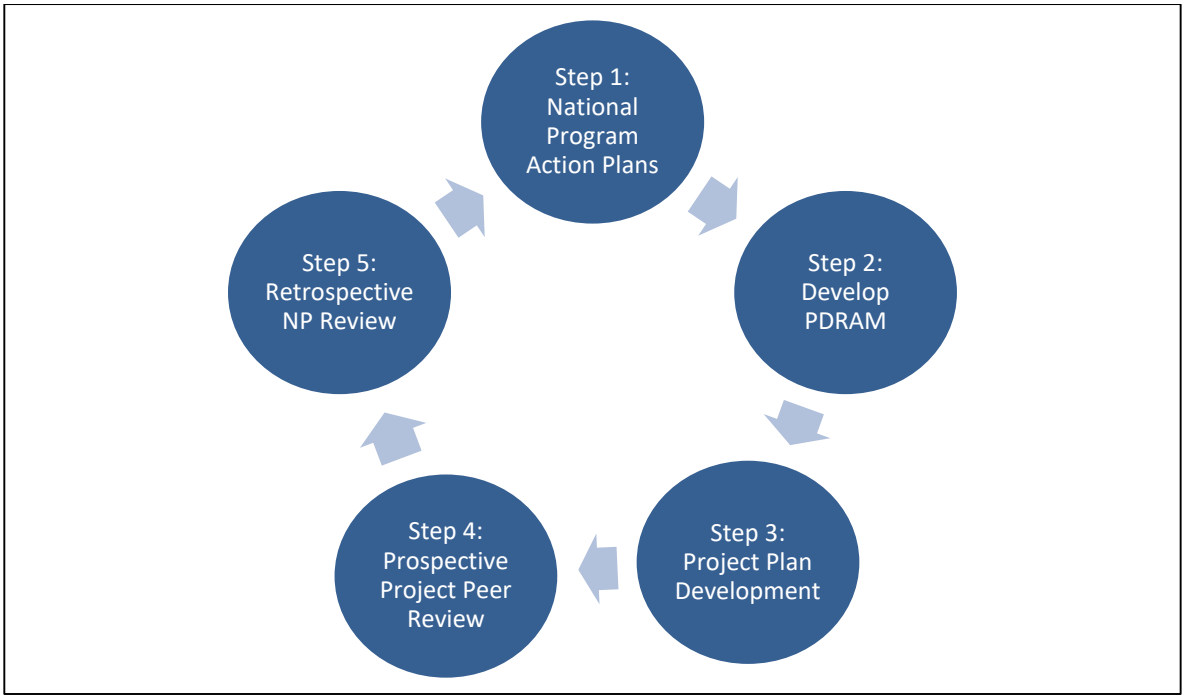

Figure 4: ARS National Program Cycle. (Source: chart created by the National Academy of Public Administration based on ARS National Program Cycle Handbook)[43]

Step 1: Develop 5-Year National Program Action Plans

Each NP must first develop a 5-year Action Plan that identifies high-level objectives, anticipated products and benefits, and the resources required to implement the Action Plan's objectives. These plans must also show how their objectives connect with the goals of the ARS Strategic Plan.

[43] U.S. Agricultural Research Service. 2017. "National Program Cycle Handbook." Beltsville, May 23. [ARS internal document].

In developing Action Plans, NPLs draw on input from external stakeholders and customers through national and regional workshops. These workshops have increasingly been held virtually, due in part to limited funds for travel.

While workshops are the primary mechanisms used for gathering program-level input, other mechanisms do exist. For example, ARS may solicit input from stakeholders through written response, various social media tools, and stakeholder input websites.[44] ARS may also conduct reviews of its own locations. Such reviews provide scientists with information and guidance from stakeholders on program direction, if programs need to change course, or if their locations are being reorganized.[45]

Step 2: Develop PDRAMs

After Action Plans are completed, NPLs develop PDRAMs that define the research objectives of individual projects.[46] The purpose of a PDRAM is to provide program-level vision and direction to the field for project plan development and resource allocation. The contents of PDRAMs include information including project objectives, linkage between project objectives and Program Action Plan objectives, and sources of funds.

During this process, ADs and research leaders communicate any concerns the availability of funds to support proposed research.[47] Final PDRAMs must be approved by the DA over the relevant NPA. For approval, agreement must be reached by the NPLs, the research team, and line management on all aspects of the PDRAM.

Step 3: Develop Project Plans

A lead scientist, with input from their location research leader, develops a project plan reflecting the goals and objectives in the PDRAM and action plan.[48] The AD reviews and forwards the project plan to the NPL(s) responsible for the NP that corresponds to the project. The NPL(s) then assess the project plan to validate its objectives and approach. Then, it is sent back to the area office for final approval. Following approval, it is sent to the Office of Scientific Quality Review (OSQR), which administers the process for undertaking a prospective peer review of the plan.

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[44] This method involves a six-month process for planning and building a website that is specifically designed to gather input from stakeholders. It also includes a comment period of specific length.
[45] U.S. Agricultural Research Service. 2017. "National Program Cycle Handbook." Beltsville, May 23. [ARS internal document].
[46] Ibid., 26.
[47] Research leader: the individual responsible for allocating funds to meet research objectives at the research unit level. The research leader supervises unit scientists and ensures research units have the necessary staff, financial resources, and equipment to conduct high quality research. Research leaders conduct the annual performance evaluation of their research unit staff.
[48] Lead scientist: the principal investigator on an ARS research project.

Step 4: Conduct Prospective Peer Review of Project Plans

OSQR convenes panels comprised mostly of external experts to conduct a prospective review of approved projects. The principal investigator on a given project, along with the NPL of disciplinary jurisdiction, make recommendations to OSQR on the individual to be selected as the panel chair. The panel chair then selects the remaining panel members. Panels may include up to one ARS researcher, provided there is no conflict of interest. The purpose of OSQR panel review is not to approve or deny projects, which are base funded, but to review the technical quality of project plans and provide guidance for strengthening them.

Step 5: Conduct of Retrospective Program Assessments

During the fourth year of the cycle, the responsible NPL, or NPLs, conducts a retrospective assessment of their National Program. These assessments are intended to identify progress and challenges in meeting National Program goals, whether any deviations from plans were warranted and productive, and how future research can be focused on unmet needs for innovation. The results of retrospective program assessments are used to inform future Action Plans. The exact process for the assessment is determined based on the nature of the National Program and the preferences of the NPLs involved. There are three important stages for the assessment process:[49]

1. Conduct an in-house assessment of the program by documenting research accomplishments and progress, for presentation to external reviewers;
2. Conduct an external review of accomplishments and progress, based on the preceding documentation, focused on the research's relevance, quality, and impact;[50]
3. Record the results of the review; and inform ARS leadership of the evaluation's results.

[49] U.S. Agricultural Research Service. 2017. "National Program Cycle Handbook." Beltsville, May 23. [ARS internal document].

[50] External reviews may involve review by panels of technical experts or stakeholders, either virtually or in-person. Stakeholder input may also be gathered using survey methods.

Appendix E – Innovative R&D Management Initiatives at ARS

In response to the changing research environment, ARS has experimented with a variety of innovative R&D management initiatives to increase the impact of ARS research investments. These initiatives have been undertaken in an ad hoc manner, largely reflecting the limitations of how ARS research is funded. Six of the most recent initiatives are described in this appendix. Table 2 below summarizes the six initiatives.

Objective	ARS Initiative	Description of Initiative
Promoting Innovative Research	ARSX	Internally focused, X-prize type challenge intended to induce high-risk/high-return research aimed at addressing major crosscutting mission challenges
	Synergies / Grand Challenges	Promoting cross-program projects that offer potential synergy benefits greater than the transaction costs; systematic, but incremental, lower risk research, but potentially high-impact
Building Enterprise Capabilities	Breeding Insights	Intended to make new genetic engineering capabilities available to plant breeding research efforts across ARS.
	Partnerships for Data Innovations	Central repository for ARS data, data visualization, overall standardization and user-friendly access to data for researchers.
	SCINet	An effort at ARS to improve USDA's research capacity by providing scientists with access to high performance computer (HPC) clusters, cloud computing, improved networking for data transfer, and training in scientific computing.
	Virtual AI Center of Excellence	This center of excellence will build on ARS' current high performance computing environment and SCINet, and will look to buy rather than build common AI platform & toolboxes.

Table 2: Six Innovative R&D Management Initiatives at ARS as shown in Chapter 3 (Source: National Academy of Public Administration)

ARSX

The ARSX Competition is an ARS intramural award competition that will award up to $100,000 in prize money for one or more proposals that address disruptive agricultural or livestock pests and pathogens in an innovative manner with potential for scalable results.

Successful proposals will demonstrate the potential to predict, prevent, detect, control, or eliminate disruptive pests over a large geographical scale, over a large timescale, or with significant economic benefits. Below is a figure of the ARSX award process.

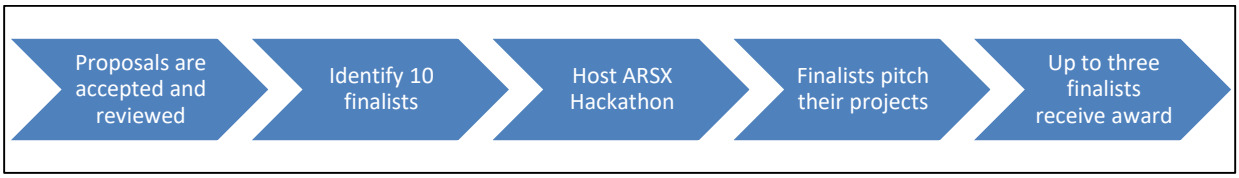

Figure 5: ARSX Award Process. (Source: National Academy of Public Administration).

The ARSX competition process has five main stages, presented in Figure 5 above.

1. Proposals were accepted until February 2020 and then assessed on potential impact and the novelty of its approach. Each proposal is evaluated by multiple independent reviewers in a transparent, double-blind process. All submissions will receive feedback.
2. Up to ten finalists are identified and chosen by this double-blind proposal review process.
3. The ten finalists are then invited to participate in the ARSX Hackathon. Generally, hackathons are competitions where several teams are competing to create prototypes on a collaborative project that innovate on a research theme or improve upon an existing project.
4. Finalists pitch their innovations to a panel of judges and an audience of their colleagues and peers.
5. Up to three finalists are chosen and award with up to $100,000 in prize money disbursed for one or more proposals.

Themes of this year's proposals must fall under the following four categories:[51]

- **Stopping Invaders at the Gate** – innovations that can prevent the introduction or provide early detection of invasive and disruptive pests and pathogens on agricultural ecosystems.
- **Strengthening Immunity** – innovations that confer enhanced resilience to disruptive pests and pathogens among agricultural crops or livestock.
- **Eliminating the Threat Within** – innovations that can lead to eradication of invasive species, disruptive pests, or pathogens without harming the natural environment or human health.

[51] U.S. Agricultural Research Service. n.d. *ARSX.* Accessed May 15, 2020. https://www.ars.usda.gov/oc/arsx/arsx/.

- **Futures Prediction** – innovations that predict the future invasion of disruptive pests and pathogens due to climate change and make information available and accessible to American farmers (e.g. public data dissemination, camera traps, social media feeds, citizen scientist generated content, geographic information systems (GIS), satellite, etc.)

ARS Synergies (formerly Grand Challenges)

ARS launched an internal initiative in 2015 with a goal of collaboration across projects, locations, and scientific disciplines to address the nation's agricultural research needs with a new level of innovation and creativity. This initiative is an integrated response to arising and ongoing challenges in agriculture and its varying stakeholders. Initially named "Grand Challenges," this initiative was renamed "ARS Synergies." ARS Synergies fosters cross-disciplinary and cross-location team science to achieve more impactful research. Projects that have taken advantage of this program include the Citrus Greening Problem Project, the Dairy Agriculture for People and the Planet Project, and Developing a Predictive Model for Vesicular Stomatitis Project. ARS Synergies projects are subject to similar requirements as a normal CRIS project. However, Synergies projects do not receive additional funding to facilitate their cross-cutting aims. ARS Synergies projects use existing resources or, if needed, NPLs and researchers can source additional external funds.

Breeding Insights

The Breeding Insight Platform (BIP) Initiative is a 5-year ARS-funded project (cooperative agreement) through Cornell University, started in 2018.[52] BIP will enable smaller ARS breeding programs to use new powerful digital tools to accelerate genetic gains. The initiative leverages recent improvements in genomics and open source informatics to accurately predict traits and performance of individual specialty crops. In addition, BIP will support breeding projects across ARS by building a team of specialists in information technology, genomics, and breeding process design. This team will then partner with individual ARS pre-breeding and breeding groups and National Plant Germplasm System gene banks. This "coordinator" type model will enable the efficient and cost-effective deployment of modern genomics and informatics to ARS small breeding programs.[53]

The initial two years of the project (2018-2020) will focus on recruiting the BIP team and integrating informatics tools. The project will leverage investments in nine open source informatics tools that are already funded by ARS, the Consortium of International Agricultural Research Centers, the United States Agency for International Development

[52] BIP is funded within the Plant, Soil, and Nutrition Research program area.

[53] U.S. Agricultural Research Service. n.d. *About Breeding Insight.* Accessed May 14, 2020. https://www.breedinginsight.org/about.

(USAID), and the Bill & Melinda Gates Foundation (BMGF).[54] Long-term, BIP will potentially more than double the efficiency of breeding programs, resulting in more sustainable, nutritious, and profitable crops. All data and intellectual property resulting from this initiative, although a joint effort between Cornell and ARS, ultimately resides and belongs to Cornell University.

Partnerships for Data Innovations

ARS developed the Partnerships for Data Innovations (PDI) in 2019.[55] PDI is a multi-organizational effort led by ARS to break down data silos across ARS and with its stakeholders, develop a data toolkit for ARS researchers, and increase the impact of data within the ARS enterprise. Previously, there was no central repository of data. Data resided within individual research centers or with individual researchers. PDI is being led by the NPL for engineering and includes public-private partnerships with organizations like Esri and Microsoft. PDI has several goals, including[56]:

- Eliminate "data silos";
- Develop a common cloud-based platform for ARS development models and tools;
- Empower ARS data managers;
- Improve data collection efficiencies; and
- Develop common service labs or resources.

As part of an effort to eliminate "data silos", PDI created Agricultural Collaborative Research Outcomes Systems (AgCROS). AgCROS is a growing "network of networks" that presently consists of multiple agricultural data networks. AgCROS facilitates the flow of information and increases cooperation among researchers by integrating these diverse database networks. PDI continues to expand AgCROS, and in 2020 will integrate datasets from NOAA, USGS, and other agencies, including continuous monitoring data from meteorology servers in June 2020. Next steps for PDI in 2020 include: expanding AgCROS, developing the Regional Unmanned Aerial Vehicles (UAV) labs concept (directed in Senate Report accompanying FY20 appropriations); completing pilot testing of the Regional Manure, Plant, Soil, and Water lab, and expanding the Airband pilot to four additional sites (this initiative bring high-speed broadband to rural areas). [57]

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[54] Ibid.
[55] Elliot, Scott. 2019. *Partnerships for Data Innovation: Realizing the Benefits of Data and the Power of Technology.* October 11. Accessed May 12, 2020. https://www.ars.usda.gov/news-events/news/research-news/2019/partnerships-for-data-innovation-realizing-the-benefits-of-data-and-the-power-of-technology/.
[56] Ibid.
[57] Elliot, Scott. 2019. *Partnerships for Data Innovation: Realizing the Benefits of Data and the Power of Technology.* October 11. Accessed May 12, 2020. https://www.ars.usda.gov/news-events/news/research-news/2019/partnerships-for-data-innovation-realizing-the-benefits-of-data-and-the-power-of-technology/.

SCINet

SCINet is an effort at ARS to improve USDA's research capacity by providing scientists with access to high performance computing clusters, cloud computing, improved networking for data transfer, and training in scientific computing.[58] Previously, ARS scientists used academic sources with HPCs for their computing analysis.

Key features of the SCINet initiative include[59]:

- Users can access ARS' high-performance computing cluster from anywhere, including ARS locations, universities, and personal residences;
- Fast data transfer storage solutions for users of SCINet; and
- Command line access and tools, including container support.

ARS runs three HPC clusters, located in three locations across the United States. In addition to the ARS in-house compute infrastructure, ARS provides access to and allows researchers to augment their capacity with Amazon Web Services cloud resources.

Currently, ARS is expanding its capacity beyond genomics. It has documented four different use cases for SCINet.

- Genomics
- Plant Breeding
- Geospatial Research
- Hydrology

SCINet is guided by the Acting Chief Science Information Officer and an Executive Committee with input from a Scientific Advisory Committee.

Virtual AI Center of Excellence

ARS has recently created a Virtual Center of Excellence for artificial intelligence (AI), which is being executed under the SCINet initiative. The purpose of this COE is to:

- Provide strategic leadership on the application of AI in agricultural research;
- Identify use cases, practices, techniques, and tools which could be applied across ARS;
- Build human resource capacity through training, strategic hiring, and recruitment;
- Advise on an ARS-funded AI Innovation Fund;
- Identify and initiate partnerships with industry and academic partners; and

[58] U.S. Department of Agriculture. 2020. SCINet Scientific Computing Initiative. May 1. Accessed May 14, 2020. https://scinet.usda.gov/.
[59] Ibid

- Define, collect, and evaluate metrics for the impact of COE activities.

An AI Innovation Fund was recently created with $2 million available in FY2020. The COE will build on ARS' HPC environment and will buy rather than build common AI platforms and tools.

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