NRSP Review Committee 2023 new and renewing proposals (NERA to make recommendations)

Proposal to Renew *NRSP8: National Animal Genome Research Program*
Enclosed Materials

1) Original proposal: The original proposal, which was loaded in the online version of NIMSS.
2) Response to Review: The "Response to Review" document is very comprehensive and includes each peer reviewer's comment followed by the writing committee's response, uploaded as an attachment in NIMSS.
3) Revised Proposal: The proposal with revisions made in response to review, uploaded as an attachment in NIMSS. – **NERA is asked to make recommendations on this draft of the proposal**.
4) Edited Budget: The NRSP8 Budget as edited in response to review, uploaded as an attachment in NIMSS.
5) Letters of Support: Numerous letters and a table of contents listing all letters at a glance.
6) Joint Summary Review: The NRSP8 Administrative Advisers conducted a joint summary review of the proposal.

Proposal to Initiate *NRSP11: Building Collaborative Research Networks to Advance the Science of Soil Fertility: Fertilizer Recommendation Support Tool (FRST)*
Enclosed Materials

1) Original proposal: Received in 2022 and considered as a request to draft an NRSP proposal.
2) Proposal draft reviewed by peers: Incorporated recommendations from the NRSP RC in response to the original proposal.
3) Peer reviews: full text of 4 completed peer reviews.
4) AA evaluation of draft proposal: Full text of the Administrative Advisers' evaluation of the draft proposal.
5) Writing Committee response: Response to reviewer comments entered as a Technical Response in NIMSS
6) Revised Proposal: The proposal with revisions made in response to review, uploaded as an attachment in NIMSS. – **NERA is asked to make recommendations on this draft of the proposal.**
7) Joint AA Review of Responses to Peer Reviewers: Administrative Advisers' review of the revised proposal after peer review.

NRSP_temp8: National Animal Genome Research Program

Status: Draft Project

Duration	10/01/2023 to 09/30/2028
Admin Advisors:	[Joe Cassady] [John Kirby] [Steven Lommel] [Noelle E. Cockett]
NIFA Reps:	

Statement of Issues and Justification

Prerequisite Criteria

How is the NRSP consistent with the mission?

A. Addressing NRSP Mission

Background. The National Animal Genome Research Program (NAGRP), NRSP-8, has been hugely successful, exceeding all expectations, by delivering complete genome sequences of seven agricultural animal species (pig, cattle, sheep, goat, horse, chicken and turkey) and providing genetic tools and resources that have revolutionized the animal breeding industry. Genome-enabled technologies developed under NRSP-8 are now integral components of commercial animal breeding and production for many species, resulting in a multifold return on investment to US stakeholders and producers. These successes, along with concomitant advances in genomics-enabled technologies, resulted in the release of the 2018-2027 USDA Animal Genome Blueprint (1) which outlines key areas for future research and funding. A crucial element identified in this report is "Science to Practice", which is the application of genomics-enabled technologies to traits and phenotypes critical to animal industries. The "Science to Practice" goals are undoubtedly attainable, in large part because of the genetic resources and technologies developed through NRSP-8.

This proposal leverages the significant accomplishments and products of the NRSP-8 program, but in contrast to previous requests for renewing NRSP-8, the new project will redirect its objectives and focus solely on capacity development. Importantly, we will expand the NRSP-8 community to include direct involvement of additional stakeholders, including non-genomics scientists and researchers, Extension personnel, and animal industry representatives. Moreover, increasing capacity that enables the application of genomics to animal traits and phenotypes will require the development of linkages with data scientists, a group that has not to date been a significant part of NRSP-8. Integration of genomics and data science, and more specifically, bioinformatics, which is the computation and analysis of biological data, will link genome data with phenome data in a very deliberate way. Animal industries are increasingly employing data collection technologies in all aspects of production, performance, health and welfare. Examples of applying data science to animal industries include image analysis to investigate tail-biting in pigs (2), Radio Frequency Identification (RFID) for studying cattle grazing behaviors (3), gait analysis of horses using neural network analysis of video data (4) and machine learning algorithms to predict health issues in aquaculture systems (5). Linking these incredibly rich datasets with genomic information and tools will provide new opportunities for US animal agriculture and accomplish the goals of the USDA Animal Genome Blueprint.

The realization of this vision will require the development of enabling capacity that is not covered under current competitive grant programs. In addition, initial conversations that have occurred between NRSP-8 constituents and industry representatives about their industry's specific needs must be continued and expanded, thereby developing knowledge, trust and understanding among the two groups. Key to these conversations are our land grant Extension personnel who are uniquely positioned to deliver new knowledge and applications to animal industries and in the opposite direction, they can ensure that current production issues are at the forefront of research objectives. In addition, novel collaborations of NRSP-8 researchers with a broad range of data scientists will further develop capacity for integrating new data types into animal agriculture research. Underpinning these efforts, we must ensure that a broad and diverse group of animal researchers, beyond just animal genomicists, are prepared to utilize data science techniques (including bioinformatics) to support innovation in US animal industries. With this in mind, ***we propose a national multi-institutional capacity project to develop the infrastructure and expertise required to apply genomics-enabled technologies to US animal industries.***

Supporting the NRSP Mission. The overall goal and specific objectives of this proposal are directly aligned with the mission of the NRSP through development of enabling technologies and by providing training and education that support the application of genomics across the complete range of agricultural animal sciences and species. By bringing together researchers in animal science, data science and genomics, as well as Extension faculty and industry representatives, we will accomplish what could not be realized by individual efforts or by animal genomicists alone. The opportunity to coordinate discussions and develop collaborations will provide a set of guiding principles and resources which can then be applied to research projects across the country. Moreover, we anticipate that the opportunities provided by multi-disciplinary interactions will create novel Research, Education and Extension links focused around the application of genomics to animal industries.

Supporting State Agricultural Experiment Stations: The Land Grant mission is focused on student-centered education to develop the 21st century workforce, delivery of cutting-edge discoveries that advance knowledge in state and national need areas, and providing outreach that educates and elevates individuals, families and communities. This proposal, which focuses on the development of capacity, responds to all three areas. In addition, the application of genomics-enabled technologies ensures that US agriculture remains globally competitive, enhances US food security and safety, supports sustainable production innovation, and provides actionable information that informs regulatory policies.

How does the NRSP pertain as a national issue?

Rationale

Priority Established by ESCOP/ESS

A. Priority Established by ESS

This proposal supports Grand Challenges identified by the ESCOP Science and Technology Committee (STC) Science Roadmap for Food and Agriculture (2020) as outlined below.

Grand Challenge 1: Enhancing the sustainability, competitiveness, and profitability of US food and agricultural systems. Developing capacity that links genomics technologies with key production, performance and welfare phenotypes will address this grand challenge by:

- maximizing capacity to enhance animal production and performance using genomics and developing new animal breeds and stocks to support diverse and resilient agricultural systems;
- applying technologies to improve animal health, well-being, and welfare in all production systems;
- enhancing nutrition efficiency and sustainability, productivity, and quality of food products in agricultural systems; and
- improving technologies for animal waste utilization and management to reduce the environmental impact of agricultural production systems.

Moreover, these outcomes also directly align with USDA Strategic Plan (7) Strategic Goal 2 (*Ensure America's Agricultural System is Equitable, Resilient, and Prosperous*), particularly by protecting animal health and fostering agricultural innovation.

Grand Challenge 2: Adapting to and mitigating the impacts of climate change on food, feed, fiber, and fuel systems in the United States. Developing capacity to apply omics technologies to animal industries supports this grand challenge by:

- applying precision agriculture for developing resilient animal lines and breeds adapted to local and to changing conditions;
- developing and sharing new, rapid breeding technologies to effectively respond to emergent vulnerabilities as microclimates become suitable for previously non-threatening diseases and pests and freshwater resources become limited;
- generating new livestock models focused on heat stress and greenhouse gas mitigation in livestock facilities; and
- acquiring and sharing accessible phenotypic data to support decision systems that integrate animal management with changing climate forecasts.

These outcomes also directly align with USDA Strategic Plan (7) Strategic Goal 1 (*Combat Climate Change to Support America's Working Lands, Natural Resources*) by building capacity to adapt to the consequences of climate change and reducing greenhouse emissions.

Grand Challenge 3: Supporting energy security and the development of the bioeconomy from renewable natural resources in the US. The integration of animal genetics with phenotypes plays an important role in the US bioeconomy (8). Examples of how the capacity developed under this proposal will support this grand challenge include:

- continuing development of sustainable animal-sourced food products;
- developing animal-based bioeconomies to support the revitalization of rural areas;
- identifying and preserving biodiversity of animal-based bioeconomies; and
- developing and sharing information to support innovative systems for reducing, recycling or reusing agricultural waste.

*Grand Challenge 4: Ensuring a safe, secure, and abundant food supply for the US and the world*Developing capacity to apply omics technologies to animal industries supports this grand challenge via:

- increased information about optimal management strategies for reducing bioactive compounds such as antibiotics and pharmaceuticals;
- information that informs effective food production regulatory policies by the USDA, FDA, Environmental Protection Agency (EPA), and other federal agencies;
- support for technologies that maximize the genomic potential of animals for enhanced productivity and quality;
- creation of novel breeding programs that balance and optimized nutritional value with production characteristics;
- development of direct collaborative links between research institutions and industry to promote the translation of new knowledge into practical applications; and
- mechanisms for cooperative international initiatives that globally enhance food safety, security, and abundance.

In addition, these outcomes support USDA Strategic Plan (7) Strategic Goal 4 (*Provide All Americans Safe, Nutritious Food*), in particular preventing foodborne illness and protecting public health.

*Grand Challenge 5: Improving human health, nutrition, and wellness of the US population*Developing capacity for omics technologies combined with the ability to capture key industry phenotypes will support this challenge in the following ways:

- develop animal food products with enhanced nutrition;
- enhance the use of animal models in human medicine; and
- support the use of animal-assisted therapies in human rehabilitation and wellness.

Grand Challenge 6: Heightening environmental stewardship through the development of sustainable management practices. The capacity developed by this proposal underpins innovations that can support:

- sustainable feeding and pest management strategies for livestock production systems;
- mitigation of methane emission from ruminants through combined genetic-dietary approaches;
- enhanced feeding practices to reduce nitrogen waste from livestock systems;
- support for precision agriculture approached to reduce chemical/antibiotic use and waste runoff;
- information to increase our understanding of ecological interactions that occur in animal industries; and
- advanced production of fish, shellfish, and aquatic plants in aquaculture systems through application of omics technologies and advanced selective breeding and domestication.

In addition to its alignment with the ESCOP STC Grand Challenges and the USDA Strategic Plan (2022-2026), the objectives of this proposal align directly with the USDA Blueprint for Animal Genome Research (1). This report highlighted progress towards assembling genomes for agriculturally relevant animals and identifying genomic and sequence variants. The report also provided examples of how these techniques and knowledge had been applied to animal industries. However, the report notes that “understanding these genomic effects is now limited by the phenotypes that are collected”. Finally, the 2021 Threats to Food and Agricultural Resources report released by the US DHS and ODNI Analytic Exchange Program outlined grand challenges to US food security (9) including: “*The US government should lead research coordination of public-private partnerships for [agricultural] information sharing standards and risk mitigation*” and “*The US government needs to promote domestic aquaculture for food production*”.

In sum, the goal of this proposal is to make genomic techniques and knowledge widely accessible to a broad range of researchers and stakeholders and to leverage data science expertise so that phenomic data collection and integration with genomic information are expanded, enhanced and coordinated. These actions will significantly increase national food animal production capabilities.

Relevance to Stakeholders

1. Stakeholders and their needs

Stakeholders will be included in this project based on their ability and commitment to enhancing the application of genomics into the animal industries. These groups are:

- Animal science researchers: This proposal supports the development of genomics expertise that will lower barriers for a broad group of researchers so they can effectively apply genomics to their research.
- Future animal scientists: This proposal will provide education and training opportunities for animal science students, as well as develop links with industry stakeholders who can provide internship placements and support novel collaborations for the students.
- Breed associations: An important goal of this proposal is to engage with representatives of breed associations to identify their needs and to ensure that they can access and apply resources, tools and expertise developed by this proposal.
- Animal breeders: We will continue to support the needs of animal breeders by developing shared cyberinfrastructure and providing training opportunities.
- Bioinformatic and data scientists: Many bioinformatics trained personnel are already involved in the NRSP-8 project. By including a broader group of informaticians, we will support the development of data science capacity specifically for animal agriculture and engage with data scientists who are interested in working on agricultural systems but to date have not been involved.
- Regulatory and policy offices: This project will develop capacity which helps federal agencies to apply evidence-based science and informs decision making for new policies. Well-designed and achievable polices and regulations are critical components in the application of genomics to animal industries.
- USDA directors and managers: Discussions with all stakeholders are expected to identify emerging industry needs. We will continue to work closely with USDA administration, including AFRI program managers, to develop RFPs and white papers that advance research in the needed areas.

As the capacity for applying genomics-enabled technologies to US animal industries increases, we anticipate that additional stakeholder groups will be added to the project. Furthermore, we acknowledge that the ultimate stakeholders of this NRSP are consumers and US taxpayers. Members of this project will strive to engage diverse sectors and communities in order to increase awareness and knowledge of genomics and its contribution in ensuring the sustainability of US animal agriculture.

Involving stakeholders in this proposal: As detailed in the business plan, stakeholders will be engaged in multiple aspects of this project, including key decision-making processes. First, we will establish an External Advisory Board (EAB) of industry stakeholders to ensure that project activities are focused on industry needs, and the NRSP membership will meet at least annually with the EAB. Second, we will use the existing AnGenMap and other professional mailing lists to encourage broad participation by all stakeholders, including animal scientists, breeders, Extension personnel, and educators. Third, many of the bioinformaticians involved in NRSP-8 have contacts in data science, including public data resources, databases and cyber-infrastructure platforms, as well as through professional associations. These relationships will be leveraged into this NRSP, as well as to the broader data science community, through targeted workshops and training events. This last approach will have the additional benefit of increasing awareness of opportunities for data scientists within animal agriculture. Details of how the stakeholders will be involved in this NRSP are further elaborated in the Business Plan and Integration sections.

Assessing stakeholder use of outcomes: Our assessment of stakeholder engagement with activities and resources will include quantitative and qualitative pre- and post- measures. Examples of assessment metrics include:

- Attendance of stakeholders at NRSP events and workshops
- Event and workshop satisfaction assessments
- Responses to project surveys on developing capacity
- Engagement on the project website and mailing list
- Resources developed by members of this project and their access/use metrics
- Research products that cite the use of resources and expertise developed under this project
- Collaborative links between NRSP members and with non-members
- Students attending education events and their assessment of learning goals for these events
- Internship and training opportunities supported by NRSP members and industry stakeholders.

Assessment of NSRP outcomes will be included as part of each activity. The outcomes will be reviewed annually by project members and stakeholders to ensure we continue to meet our objectives and effectively engage stakeholder groups. We anticipate that review of project outcomes and stakeholder involvement will require us to adapt to changing circumstances and emerging research objectives as the project progresses.

Contribution to public policy: Project outcomes will include resources and information that support the application of genomics to animal industries. Making genomics data more accessible and the associated analyses more reproducible will aid in development of or contribute to the discussion of public policy related to food safety, environmental protection and understanding the impacts of genetically modified animals. By increasing capacity that enables a wider range of agricultural scientists to apply genomic technologies, we broaden participation and scientific expertise that address key challenges in animal industries such as reducing the use of antibiotics in production systems, identifying approaches for animal waste utilization, improved animal health and welfare, and understanding the mechanisms and effects of genetic modifications both on animals and their production environment. US regulatory agencies will be able to utilize detailed information about the molecular basis of complex biological systems, which supports the application of evidence-based science for policy development. We will include representatives from key regulatory agencies in NRSP discussions and activities so that a diverse group of stakeholder voices are incorporated during the early stages of the project as well as in the planning of subsequent resources and directions.

2. Renewal Justification

This capacity proposal directly supports and extends the genomics capacity developed under NRSP-8, which currently has 105 members from 49 institutes. Members span 36 US states and seven countries, making it truly a national project with international collaborators. From 2018-2021, NRSP-8 was supported by OTT Multi-state Research Funding at $500,000 per year. During that same 4-year period, NRSP-8 members produced 924 publications and obtained over $43 million in competitive funding - a return on investment of more than $20 for every dollar provided to the NRSP-8 project. With a focus on future impacts, the proposed NRSP project will accelerate use and application of genomics resources that have been developed under NRSP-8, and this will be accomplished through training and education that supports assimilation of genomics-technologies across all animal science areas.

Over the last four years, NRSP-8 members have held meetings with industry stakeholders to gauge the application of genomics in their companies and production systems. Industry representatives have made it clear they want continued access to bioinformatics resources, expanded bioinformatics training, opportunities to recruit data-savvy graduates, and the ability to link genetics data with information they are collecting on animal traits and phenotypes within their operations. Thus, this new NRSP proposal will have a concentrated emphasis on animal industry needs. In demonstration of this emphasis, letters of support from industry stakeholders are included in the proposal.

Implementation

Objectives

1. Specific Aim 1: Extending genomics capacity to a broader range of Animal Science stakeholders.
   Comments: Approach: ● Survey stakeholders on data capacity needs ● Design workflows to simplify data sharing ● Develop resources (e.g., protocols.io) for genomic workflows ● Support community use of micropublications that ensure datasets are publicly available and citable ● Generate community standards for data reuse
2. Specific Aim 2: Supporting capacity to integrate genomics data with additional data types.
   Comments: Approach: ● Workshops to identify stakeholder data collection and data analysis gaps ● Roundtable discussions with data scientists to develop interdisciplinary teams ● Support for students and early career investigators, including attendance at bioinformatics and data science meetings
3. Specific Aim 3: Education, training and outreach to develop a data-savvy workforce.
   Comments: ● Development and publication of stand-alone educational modules that can be added to existing animal science courses or used as stand-alone training ● Linking educational modules with micro-certificates that signal data competencies ● Development of a mailing list/bulletin board to publicize internship opportunities between stakeholders, students and academic advisors in animal science ● Bioinformatic training workshops at meetings and conferences

Projected Outcomes

- Published report on the data management capacity needs of stakeholders. Comments: Expected impact: Knowledge to support the application of precision genomics in animal industries.
- Coordination of resources to facilitate data deposition and re-use. Comments: Expected impact: Support for data sharing and re-use to accelerate the use of omics technologies and ensure a return on investment.
- Evaluation and standardization of methods for recognition of data reuse. Comments: Expected impact: Capacity for the broader research community to effectively utilize genomics approaches.
- Exchange of ideas to identify key data collection and management needs of stakeholders. Comments: Expected impact: Development of knowledge, resources and interdisciplinary teams that can address the Grand Challenges facing agriculture.
- Published report of animal industry needs for integrating genomics and other data types. Comments: Expected impact: Capacity for precision agriculture in animal industries.
- Identifying future needs of stakeholders for integrating genomics data. Comments: Expected impact: Support for the development of sustainable, resilient and economically viable animal industries in a changing environment.
- Exchange of ideas and expertise with data science experts. Comments: Expected impact: New collaborations between scientists of diverse research areas.
- Support for students and early career investigators to attend bioinformatics and data science meetings. Comments: Expected impact: Development of a data-literate animal agriculture workforce.
- Coordination of undergraduate and graduate student educational resources. Comments: Expected impact: Development of a data-literate animal agriculture workforce.
- Identification and coordination of information about internship programs for animal science students. Comments: Preparation of a new generation of data-savvy scientists for the agricultural workforce.
- Coordination to develop informatics training opportunities. Comments: Expected impact: Opportunities for continued professional development for the animal industry workforce and partnerships between industry and academia.

Management, Budget and Business Plan

1. Business Plan:

Rationale for Modest and Sustained Support: In the last renewal period, NRSP-8 received $500,000 per year from SAES which was distributed across six species coordinators (pig, cattle, sheep/goat, horse, poultry and aquaculture at $65K per coordinator) and a bioinformatics coordinator ($110K). Members of the NRSP-8 project have been highly productive, attributing 924 publications and more than $43 million in competitive grant and contract funding to NRSP-8 from 2018 to 2021. However, the broader and more lasting impacts of the NRSP-8 project are the genomics resources and tools that were developed since the inception of NRSP-8 in 1993. These tremendous outputs will now be leveraged to future genomic discoveries in farm animal species under the new proposed project, while expanding capacity to a much broader stakeholder community. The new NRSP project's business management plan is designed to ensure that the project will function smoothly and effectively and will maximize opportunities to seek funding beyond the OTT MRF. Modest annual funding ($127,120) is requested for the first three years of the project.

Organizational Structure: An outline of the organizational structure for this project is shown in Figure 1 (*see attachment*) and indicates interaction among stakeholders, NRSP leadership and NRSP members. Briefly, the NRSP Leadership Team will consist of eight elected positions: Chair, Co-chair, and Coordinators and Co-Coordinators for each of the three specific aims described above. The leadership team will report to SAES Directors, stakeholders, and an External Advisory Board (EAB).

NRSP Leadership Team:

- Chair (elected by NRSP members): manage the logistics of the project and provide annual reports to the membership, stakeholders, SAES Directors, and EAB.
- Co-chair (elected by NRSP members): assist Chair with project responsibilities and serve as the Chair-Elect. The co-chair will move into the position of Chair after the Chair's term is completed, and a new Co-Chair will be elected by the NRSP membership.
- Coordinators (elected by NRSP members): manage activities for their respective specific aim and report on these activities and their outcomes at the annual meetings.
- Co-Coordinator (elected by NRSP members): assist with Coordinator responsibilities and ensure activities meet stakeholder needs. Co-Coordinators will ideally be elected from Extension, industry, or the stakeholder group.

External Advisory Board (EAB):

The EAB will consist of five stakeholder members. The role of the EAB is to attend the annual meeting of the NRSP project, review the annual progress reports and provide the NRSP Leadership Team with feedback about progress, activities, stakeholder needs, and the impact of capacity developed within the project.

The Leadership Team and EAB positions will have three-year terms, with the possibility of a second consecutive term if re-nominated and re-elected. Nominations for membership on the NRSP Leadership Team and EAB will be sought to reflect the range of stakeholder interests, technical expertise, career stage and institutions that encompass the NRSP membership. Nominations will then be presented in an election available to all NRSP members. The first election will be held following the notification of project approval; Drs. Fiona McCarthy (University of Arizona) and Stephanie McKay (University of Vermont) will serve as interim Co-chairs of the project until that election is held.

While the budget outlines a proposed distribution of funds, there may be revisions to the budget based on discussions between the NIFA Director, the NRSP Leadership Team and the EAB in an effort to better align resources across the project's aims and activities. Thus, adjustment(s) of the budget may be requested during the project period, and approval of the revision(s) will be sought from the administrative coordinators assigned to the project.

Planned Collaborations & Outreach: A key aspect of this proposal are the collaborations that will be facilitated in several ways with animal genomicists and:

- researchers in other subspecialties of animal sciences and their allied fields (e.g., nutrition, reproductive biology, veterinary medicine) though workshops and meetings at existing conferences (e.g., American Society of Animal Science and associated regional conferences);
- those in other data science fields in order to develop capacity in new informatic techniques that can be applied to animal agriculture;
- groups working on open data sources that support better data management and standards within animal sciences (e.g. the FAIR Initiative);
- genomics/bioinformatics resources such as CyVerse and Galaxy to ensure support for sustainable training resources;
- collaborative links with existing projects such as the USDA-funded AG2PI, the AgBioData Consortium, and NRSP-10 National Database Resources for Crop Genomics, Genetics and Breeding Research;
- related multi-state projects that have genetic improvement/data sensing themes, including:
    - NC1170 Advanced Technologies for the Genetic Improvement of Poultry
    - NECC1901 Integrating Genomics and Breeding for Improved Aquaculture Production of Molluscan Shellfish
    - WERA1 Coordinating Beef Cattle Breeding Research and Education Programs for the Western States
    - S1086 Enhancing sustainability of beef cattle production in Southern and Central US through genetic improvement
    - S1069 Research and Extension for Unmanned Aircraft Systems (UAS) Applications in U.S. Agriculture and Natural Resources

The integration of activities with these projects is described in more detail in other sections of the proposal.

Outreach effort will focus on:

Expanding genomics capacity for all animal scientists. NRSP annual meetings will alternate between the International Plant and Animal Genome (PAG) and other meetings routinely attended by animal scientists (e.g., the annual American Society of Animal Sciences meeting). Outreach to other sectors of the broader community will occur through presentations, informational sessions and training opportunities at meetings attended by animal sciences researchers and other stakeholders (e.g., the Havemeyer meeting, Beef Improvement Federation Symposium, American Sheep Industry Convention). The outreach events will include presentations on how NRSP tools and resources have been applied in various research projects and in various species/industries, discussions about specific community needs and gaps, and hands-on training for non-genomicists. These outreach efforts will inform the broader community about research capacity that is either available or being developed and will include feedback so that new developments are aligned with stakeholder needs.

Developing informatics capacity for animal industries. Bioinformatics personnel routinely attend and present at informatics and association meetings (e.g., Data Carpentries, GMOD, Galaxy, CyVerse and the International Society of Biocuration). Therefore, we will use these meetings as conduits for developing cross-collaboration information exchanges with the broader informatics field. Capacity for animal scientists will be expanded through these exchanges and scientists working in informatics and data science will learn of new opportunities for applying informatics techniques to animal industries. Partnering with these informatic associations will also provide novel opportunities to develop education and training in targeted areas as well as the recruitment of additional expertise and resources for the animal science areas.

Supporting education and training capacity. Outreach to both animal scientists and informaticians will be done through education and training programs, with a primary focus on graduate and undergraduate students at land grant colleges and universities, including the 1862, 1890 and 1994 institutions. However, online educational resources will also be available to all participants of the NRSP project. Additionally, animal breeders, industry stakeholders, Extension personnel and the general public will be provided with non-technical information on genomics-enabled technologies and their application in agriculture. In this way, the successes of genomic-based research in farm animals will be disseminated and celebrated.

The project leadership will also engage with regulatory and funding agencies to ensure broad perspectives on the needs of genomics-enabled technologies across all animal industries. These conversations will also lead to funding for additional activities of this project and new research that may be developed because of capacity expansion that are outcomes of the project.

Outcome Delivery Schedule: The key milestones of this NRSP are described below. The project Chairs and Coordinators will be responsible for ensuring that all members and stakeholders are positioned to meet the targeted deliverables.

Year 1. *Aim 1:* Produce surveys for animal science researchers; community discussion regarding data deposition guidelines. *Aim 2:* Develop initial stakeholder and data science groups for discussions via open expressions of interest.*Aim 3:* Develop test-cases for educational modules; collect information about internship opportunities; determine needs/interest for training programs.

Year 2. *Aim 1:* Distribute survey results; develop test-cases for data deposition; organize community workshops on data reuse. *Aim 2:* Hold industry-specific round tables; develop links with data science experts.*Aim 3:* Assess training modules; review and assess internship co-ordination; deliver training workshops.

Year 3. *Aim 1:* Publish survey results; assess development of data deposition guidelines; organize follow-up with stakeholders on data reuse workshops. *Aim 2:* Complete industry-specific round tables and report on industry needs.*Aim 3:* Expand educational modules; offer and evaluate internship experiences; expand training workshops; provide mid-project review and assessment of project activities.

Year 4. *Aim 1:* Distribute data deposition resources to the community.*Aim 2:* Host interdisciplinary discussions to foster collaborations. *Aim 3:* Add educational modules; offer and evaluate internship experiences; provide training workshops.

Year 5. *Aim 1:* Publish report on data reuse.*Aim 2:* Deliver outreach at bioinformatics, bio-curation and data science meetings. *Aim 3:* Assess education modules and revise as needed; review and assess internship coordination; assess training workshops and revise as needed; provide final report and assessment of project activities.

Additional sources of funding: In addition to the OTT Multi-state Research Funding (MRF) provided by SAES, members of the NRSP project will be proactive in seeking and obtaining funding from additional sources to expand resources and address issues relevant to the project. For example, NRSP-8 members have submitted a conference proposal to AFRI supporting early career scientists who want to use genomics in their research projects to attend the Advances in Genome Biology and Technology – Agriculture (AGBT-Ag) meeting in 2023. Another example of additional funding are internship opportunities that are offered by several of our industry partners. We intend to redirect these internships to this project by training students in genomics techniques and then placing the students with relevant industry partners. Additional research experiences for students will be expanded with new stakeholders offering internships. Other sources of funding that will be sought for this project include grants and industry sponsorship for meetings, and competitive funding from agencies such as AFRI, NSF and FFAR to support workforce training focused on genomics capacity.

Sustainability: This NRSP proposal includes provisions for sustaining capacity beyond the initial OTT MRF funding. Specific activities are designed to enhance competitive funding for those scientists trained through and included in this project. Also, initial assessments of stakeholder needs will form the basis of a white paper that focuses attention on the needs of the scientific community and then project members will be encouraged to develop collaborative grants, with project activities designed to enhance the grant proposals.

It should be noted that new funding that spans research, education and training workshops will be one of the measures of project impacts. Furthermore, partnering on bioinformatics resources and educational initiatives will allow us to effectively leverage existing capacity that will be directed towards helping the animal industries.

Industry stakeholders have indicated the need for employees who have expertise in data management and analysis. We will partner with stakeholders to support and develop internships and similar experiential training opportunities so that those workforce needs are met.

A key component for sustaining capacity is to ensure that genomic resources are widely dispersed and easily accessible by multiple groups and users with different levels of expertise. With support from the EAB and industry stakeholders, we will develop policies for ensuring that the resources developed within this project are disseminated. For example, we foresee the distribution of analysis workflows/software to different bioinformatic platforms (e.g., CyVerse, Galaxy, GitHub, BioContainers).

2. Budget Narrative

OTT Multistate Research Funding requested:

Salaries: We are requesting salary support to maintain the project website and email list (1 month p.a.); and summer stipends for students to develop and test bioinformatics analysis test cases (3 students each at 0.25 FTE, annually).

Fringes: Fringes are calculated at 43%.

Travel: We are requesting travel that will support EAB members attending annual meetings, training workshops, and community-stakeholder round table discussions. We also request funds to support students and early career investigators so they can attend bioinformatics/data science themed conferences. Travel costs include flights, accommodation, registration and meals.

Other: We are requesting the costs of open access publications for four reports on the outcomes of community and stakeholder discussions as well as funds for hosting the project server.

Additional sources of funding:

Project participants will be encouraged to seek additional funding to support the activities, data, resources and educational materials developed herein. NRSP-8 participants have been highly successful leveraging research funding using NRSP-8 tools and resources, with an average return on investment of more than $20 for each dollar provided to the NRSP-8 project. We intend to continue this incredible leveraged success by pursuing grant funding for conferences and meetings and education and training grants to expand and sustain the project's outreach activities. Moreover, by building stronger links with our industry stakeholders and including them in project management and decision making, we anticipate that we can obtain industry support that will offset the costs of meetings and training activities.

Figures for additional sources of funding are projected based on past support to NRSP-8 from industry partners and conference grants.

Salaries: Salary costs include support of industry research internships and university funding for summer stipends of students (1.5 students each at 0.25 FTE, annually).

Fringes: Fringes are calculated at 43%.

Travel: Travel costs include industry sponsorship of training workshops and stakeholder-focused discussions, as well as conference grants and fellowships that support students and early career investigators at bioinformatics/data science themed conferences. Travel costs include flights, accommodation, registration and meals.

Integration

1. Integration with Extension, academic, or international programs:

The proposed organizational structure is designed to ensure integration of capacity with Extension, academic and international programs. Current NRSP-8 membership is predominantly comprised of academicians with extension, teaching, and research appointments, thus promoting communication through extension and outreach with stakeholders and industry representatives. We will build upon NRSP-8 sponsored conversations with industry representatives, which requires sustained conversations to develop knowledge, trust and understanding. Finally, it should be noted that the current membership of NRSP-8 includes 105 members from 49 institutions at 36 US states and six additional countries. A historic example of NRSP-8 supported international collaboration are efforts supporting the sequencing of key livestock genomes (10–14). More recent examples of NRSP-8 supported international collaborations include FAANG and AG2PI, both of which are high priority multi-species international projects that include and benefit NRSP-8 members. International partners will also be connected at scientific meetings (e.g., ASAS, ADSA, PAG, ISAG, SSR, WCGALP).

2. Engagement in project planning and implementation

The previous NRSP-8 program resulted in numerous new partnerships within the last five years. During this time, we held three stakeholder panels with representatives from all major USDA animal genome species. Industry participants represented both US and global animal industries, as well as animal genetics companies and breed associations. The feedback provided by these participants has been essential for developing the aims of the current proposal. During the same period, we created partnerships within the international FAANG and note that this project was initially proposed and developed as a direct consequence of the NRSP-8 project. Other partnerships that have developed from NRSP-8 activities include the AFRI funded projects developing pangenome resources for chicken, sheep, and cattle; several competitively funded telomere-to-telomere sequencing projects; the Agricultural Genome to Phenome Initiative (AG2PI), funded through the US Farm Bill; and strengthened linkages between NRSP-8 members and the AgBioData and NRSP-10 projects.

While NRSP-8 has been highly successful, ***this proposal is substantially different from the NRSP-8 project*** Funding for the NRSP-8 Species and Bioinformatics Coordinators is not requested in this project, and genomics tools and resources will not be the primary focus. Instead, the overall objective is the development of new genomics capacity across a multitude of areas. The project's implementation leverages lessons learned within NRSP-8. For example, we anticipate a smooth transition from NRSP-8 to the new leadership team by designating two active NRSP-8 members to serve as the first Co-chairs of the project and then electing chairs and coordinators from the new project's members. Stakeholders are engaged via the EAB and through individual activities that span the duration of the project. Members will be asked to identify their interest in specific aims and activities, and all members will be updated on all aims and activities at the annual meeting and via the annual written report. Moreover, all members are involved in selecting the NRSP's leadership team via the nomination and election processes.

3. Integration with multistate projects

This project will provide critical data and training resources to allow a wide range of scientists and researchers to use genomics and phenomics tools in their sub-disciplines of animal science. New workflows and case studies will be designed for connecting genomics with emerging technologies that are coming forward in animal agriculture. For example, the sensing and high-throughput phenotyping that validates behavioral responses in farm animals could be analyzed to identify the underlying genetics that control behavior. The project will also provide training through workshops associated with scientific meetings, websites and other virtual materials to the broader animal sciences community. Training will include sessions on a variety of topics such as how to use new analysis software, best practices when conducting genomic analyses, identifying phenomic patterns and anomalies, and reusing (and archiving) previously collected data. It is anticipated that training may also be needed for new statistical approaches such as machine learning and AI. Obviously, these training modules will be useful to a wide range of discipline- specific multistate projects related to animal science and will also be pertinent in agricultural engineering and other related fields. Our plans for integration with other multi-state projects are outlined in the Business Plan.

Outreach, Communications and Assessment

1. Communication Plan:

Target Audience. The primary beneficiaries of this NRSP include:

- Research scientists directly engaged in animal genetics, genome research, and animal breeding.
- Scientists utilizing publicly accessible genomic data in their respective animal science fields as well as complementary research in veterinary medicine, human physiology and medicine, bioinformatics, data science, biology, ecology, and rangeland science.
- Faculty, researchers, and graduate and postdoctoral students who want to apply new techniques in animal genomics to their research projects.
- Stakeholders, as defined and described in previous sections.

Support of research, education, and communication activities in animal genomics also benefits public consumers of US animal agriculture products. Outcomes include improvements in the quality, safety and wholesomeness of animal products, economic efficiencies, and environmental stewardship of animal production systems.

Communication Plan. The primary mechanism for distribution of NRSP results and accomplishments will be via annual reports publicly available on NIMSS (https://www.nimss.org/). However, we will also disseminate information about our activities and outcomes via peer-reviewed publications, white papers, and conference presentations. These products will be listed in the annual report posted on NIMSS and through other public channels, such as journal websites and relevant press releases. To engage with stakeholders and promote the project, these communications will also be featured on the project website, which will also contain training and educational resources developed within the project. The website will also be integrated into a list-serv that allows direct connection with members and stakeholders for disseminating information about upcoming project activities and opportunities.

2. Stakeholder engagement:

Our stakeholders are defined and described in the previous section, and details on how they will be integrated into this project are outlined in the Business Plan section. Briefly, stakeholders will be engaged at multiple points and will have an important role in shaping the outcomes of this project. Examples of stakeholder engagement are:

- A stakeholder advisory group (the Executive Advisory Board) will be created and meet annually with the project Leadership Team. The EAB will be critical in obtaining feedback on how project activities meet stakeholder needs.
- Stakeholders will be included on the project list-serve, which will be used to promote communication and dissemination of project activities and outcomes.
- Stakeholders will be encouraged to attend the annual project meetings.
- Workshops and training modules will be designed and focused on stakeholder needs.
- Surveys and discussions with stakeholders representing diverse industries and priorities are incorporated throughout the three Specific Aims.
- Experiential internships will link stakeholders with students, creating pipelines for data-savvy future employees as well as identify gaps in student knowledge.

3. Measuring accomplishments and outcomes:

The accomplishments of capacity-building projects are measured in terms of resources development, interdisciplinary collaborations, and knowledge transfer. The project Leadership Team will document accomplishments in annual progress reports, including:

- Published protocols and case studies that support bioinformatics analysis of animal genomics data sets and their integration into existing bioinformatics workflows.
- Development and use of guidelines to support best practice in bioinformatic analysis of genomics data sets and the reuse of data.
- Reports, white papers and publications describing outcomes from workshops, roundtables, and training events.
- Attendance of stakeholders at NRSP activities, including training workshops.
- Development of training, education and Extension materials and opportunities.
- Students participating in experiential education and internship opportunities.
- Publications and grant submissions that are outcomes of new collaborative opportunities established through this project.

Methods to measure program accomplishments have been described in previous sections of this proposal and include:

- An annual request from the Specific Aim Coordinators to all program participants to provide information on accomplishments and publications linked to the project.
- Routine searches of scholarly repositories, journal articles and professional reports.
- Compilations of project website use statistics.
- Participation in NRSP activities.

The impact of these accomplishments lies in their successful application to animal industries. This will be assessed by measuring usage of resources (e.g., online access and downloads), number of people who complete training and education activities, citations and downloads of publications and reports, stakeholder participation in the activities, and the ability of members to leverage project resources, activities and collaborations into research, education, extension and conference grants across federal and state agencies, as well as to research and philanthropic foundations.

4. Development of communication pieces:

The Leadership Team will organize annual reports which include accomplishments, outcomes and impacts. The report will be shared with NRSP members and stakeholders via the NIMSS reporting system and the project website and list serve. The Leadership Team and the External Advisory Board will identify a subset of project impacts and accomplishments that will have broader distribution across the Multistate Research Fund Impacts Program, State Agricultural Experiment Stations and leadership of the land-grant universities. As outlined above, project accomplishments and outcomes will also be disseminated at scientific conferences and professional association meetings.

5. Data management plan:

The goal of this capacity proposal is not to directly fund the acquisition of new data tools and resources but rather to support scientists who are using or wish to use them. NRSP members will be trained in best practices for data management, including analysis, sharing, and re-use of data. Members are expected to support responsible data management and routinely meet or exceed federal and community data management policy and best practices. This includes agreement to abide by the Toronto principles for data release, the Fort Lauderdale policy for rapid pre-publication release of data sets, and federal data sharing policies and requirements, including the USDA Guidelines for Data Management Planning. Goals of this project include the support of members in meeting these standards and to develop best practices for sharing data within the constraints of established commercial confidentiality.

Resources developed as a direct result of this project will be managed, archived, and made available to prospective users via publication in scientific journals, dissemination at meetings and conferences, through the project website and indirectly through links to other well-established platforms for resource sharing (e.g., GitHub, biocontainers, bioinformatic platforms and protocols.io).

6. Suggested mechanisms for distribution of the results of the research support project.

Many of the NRSP-8 coordinators and members have held advisory roles with USDA or other US agencies, offices, departments, or committees including:

- USDA ARS
- USDA APHIS
- USDA NIFA Southern Regional Aquaculture Center
- US DHS Analytic Exchange Program
- US DHS Cybersecurity and Infrastructure Security Agency
- US DHS Countering Weapons of Mass Destruction
- National Oceanic and Atmospheric Administration
- White House Rural Council.

As such, the NRSP-8 community expertise is well respected and communication channels to a diverse set of stakeholders are already in place. Furthermore, industry contacts serve in advisory roles for NRSP-8 and they provide and receive input that guides the research community. The NRSP-8 membership represents 49 institutions across 36 US states and six additional countries. Our established mailing list includes additional parties interested in this work, representing more than 3,000 individuals from 50 countries. These connections and networks will be used to distribute project results from the new project both nationally and internationally.

As described in previous sections, our goal is to have the project resources and reports widely disseminated, and this will ensure that the capacity developed by this project is sustainable after the funding is completed. While resources and accomplishments will be available on the project website, we expect that they will primarily be distributed to the community via well-established sharing platforms such as existing bioinformatics platforms (e.g., Galaxy, GitHub, Biocontainers, Data Carpentries and Protocols.io). These resources already have active communities and expertise for us to leverage and familiarity with these resources will also help our community to develop additional expertise and collaborations. Resources developed as part of this NRSP will acknowledge NIFA Hatch funding, and members will be provided with reminder and suggested language for this. Resources and accomplishments will also be shared at the annual meetings, which will be associated with regular conferences and meetings to support outreach to our stakeholders.

Literature Cited

1. Rexroad C, Vallet J, Matukumalli LK, Reecy J, Bickhart D, Blackburn H, et al. Genome to Phenome: Improving Animal Health, Production, and Well-Being – A New USDA Blueprint for Animal Genome Research 2018–2027. Frontiers in Genetics [Internet]. 2019 [cited 2022 Aug 17];10. Available from: https://www.frontiersin.org/articles/10.3389/fgene.2019.00327
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Organization/Governance

Literature Cited

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Land Grant Participating States/Institutions

MN,AR,IA,TX,OK,MO,VT,IL,CA,NC,WA,HI,AZ,PA,MI,FL,NE,ID

Non Land Grant Participating States/Institutions

University of Sydney

Participation

Participant	Is Head	Station	Objective	Research						Extension	
				KA	SOI	FOS	SY	PY	TY	FTE	KA
Brooks, Samantha A		Florida - University of Florida	1,2,3	304	3810	1080	0.70	0.50	0.30	0	0
Ciobanu, Daniel	Yes	Nebraska - University of Nebraska	1,2,3	303	3510	1080	0.20	0.20	0.20	0	0
Da, Yang		Minnesota - University of Minnesota	2	303	3410	1080	0.10	0.00	0.00	0	0
Dekkers, Jack		Iowa - Iowa State University	1,2,3	303 303 304 304 304 304	3210 3220 3510 3510 3910 3980	1080 1080 1080 1081 1080 1081	0.40	0.40	0.00	0	0

Participant	Is Head	Station	Objective	Research						Extension	
				KA	SOI	FOS	SY	PY	TY	FTE	KA
Gondro, Cedric		Michigan - Michigan State University	2,3	303	3910	1081	0.10	0.00	0.00	0	0
Hagen, Darren		Oklahoma - Oklahoma State University	1,2,3	304 304	3999 3999	1080 1040	0.10	0.00	0.00	0	0
He, Yanghua		Hawaii - University of Hawaii	1,2,3	303 304 304 304	3220 3310 3410 3610	1040 1060 1080 1081	0.10	0.00	0.00	0	0
Jiang, Jicai		North Carolina - North Carolina State University	2,3	303 303	3499 3599	1080 1080	0.10	0.00	0.00	0	0
Jiang, Zhihua		Washington - Washington State University	1,2	304 304	3320 3499	1080 1080	0.10	0.00	0.00	0	0
Kim, Tae Hyun		Pennsylvania - Pennsylvania State	1,2,3	304	3210	1080	0.45	0.00	0.00	0	0
Koltes, James E		Iowa - Iowa State University	1,2,3	304 304	3410 3410	1080 1081	0.50	0.00	0.00	0	0
Liu, Wansheng	Yes	Pennsylvania - Pennsylvania State	1,3	301 303 304 301 301 303 304 301	3310 3310 3310 3410 3410 3410 3410 3310	1080 1080 1080 1080 1040 1080 1080 1040	0.57	0.00	0.00	0	0
McCarthy, Fiona	Yes	Arizona - University of Arizona	1,3	304 304 304	3910 3199 4099	1040 1080 0	0.20	0.00	0.50	0	0
McCoy, Annette	Yes	Illinois - University of Illinois	1,2,3	305 304	3810 3810	1080 1080	0.10	0.00	0.00	0	0
McCue, Molly	Yes	Minnesota - University of Minnesota	1,2,3	304	3810	1080	0.10	0.00	0.00	0	0
McKay, Stephanie D		Vermont - University of Vermont	1,2,3	304 304 304	3399 3499 3699	1080 1080 1080	0.10	0.00	0.00	0	0
Neibergs, Holly L		Washington - Washington State University	1,2	303 303 304 304	3310 3410 3310 3410	1080 1080 1080 1080	0.10	0.00	0.00	0	0
Phelps, Michael		Washington - Washington State University	1,2,3	305	3711	1040	0.10	0.00	0.00	0	0
Rhoads, Douglas		Arkansas - University of Arkansas	1,3	303 303 303	3220 3220 3220	1080 1040 1081	0.10	0.10	0.00	0	0

Participant	Is Head	Station	Objective	Research						Extension	
				KA	SOI	FOS	SY	PY	TY	FTE	KA
Riggs, Penny K		Texas AgriLife Research	1,2,3	304 304 306 701	3320 3320 3310 3320	1040 1080 1080 1040	0.20	0.00	0.00	0	0
Schnabel, Robert	Yes	Missouri - University of Missouri	2,3	304 304	3399 3499	1080 1080	0.10	0.00	0.00	0	0
Tammen, Imke		University of Sydney	1,2,3	303 304	3610 3310	1080 3030	0.10	0.00	0.00	0	0
Zhao, Ningning		Arizona - University of Arizona	2	304 304	3899 3840	1040 1040	0.20	0.20	0.50	0	0
Zhou, Huaijun		California -Davis : University of California, Davis	1,3	303 304 306 311	3210 3220 3510 3220	1081 1090 1040 1080	0.10	0.00	0.00	0	0

Combined Participation

Combination of KA, SOI and FOS	Total SY	Total PY	Total TY
304-3810-1080	0.1	0	0
303-3410-1080	0.1	0	0
303-3220-1040	0.03	0.1	0
303-3220-1080	0.03	0.1	0
303-3220-1081	0.03	0.1	0
303-3210-1080	0.07	0.4	0
303-3220-1080	0.07	0.4	0
304-3510-1080	0.07	0.4	0
304-3510-1081	0.07	0.4	0
304-3910-1080	0.07	0.4	0
304-3980-1081	0.07	0.4	0
304-3320-1040	0.05	0	0
304-3320-1080	0.05	0	0
306-3310-1080	0.05	0	0
701-3320-1040	0.05	0	0
304-3999-1040	0.05	0	0
Grand Total:	**5.42**	**1.40**	**1.50**

Combination of KA, SOI and FOS	Total SY	Total PY	Total TY
304-3999-1080	0.05	0	0
304-3399-1080	0.05	0	0
304-3499-1080	0.05	0	0
304-3399-1080	0.03	0	0
304-3499-1080	0.03	0	0
304-3699-1080	0.03	0	0
304-3810-1080	0.05	0	0
305-3810-1080	0.05	0	0
303-3210-1081	0.03	0	0
304-3220-1090	0.03	0	0
306-3510-1040	0.03	0	0
311-3220-1080	0.03	0	0
303-3499-1080	0.05	0	0
303-3599-1080	0.05	0	0
304-3320-1080	0.05	0	0
304-3499-1080	0.05	0	0
303-3220-1040	0.03	0	0
304-3310-1060	0.03	0	0
304-3410-1080	0.03	0	0
304-3610-1081	0.03	0	0
304-3199-1080	0.07	0	0.5
304-3910-1040	0.07	0	0.5
304-4099-0	0.07	0	0.5
301-3310-1040	0.07	0	0
301-3310-1080	0.07	0	0
301-3410-1040	0.07	0	0
301-3410-1080	0.07	0	0
303-3310-1080	0.07	0	0
303-3410-1080	0.07	0	0
Grand Total:	**5.42**	**1.40**	**1.50**

Combination of KA, SOI and FOS	Total SY	Total PY	Total TY
304-3310-1080	0.07	0	0
304-3410-1080	0.07	0	0
303-3910-1081	0.1	0	0
303-3610-1080	0.05	0	0
304-3310-3030	0.05	0	0
304-3810-1080	0.7	0.5	0.3
304-3840-1040	0.1	0.2	0.5
304-3899-1040	0.1	0.2	0.5
303-3510-1080	0.2	0.2	0.2
304-3210-1080	0.45	0	0
304-3410-1080	0.25	0	0
304-3410-1081	0.25	0	0
303-3410-1080	0.13	0	0
303-3699-1080	0.13	0	0
304-3399-1080	0.13	0	0
304-3699-1080	0.13	0	0
303-3310-1080	0.03	0	0
303-3410-1080	0.03	0	0
304-3310-1080	0.03	0	0
304-3410-1080	0.03	0	0
305-3711-1040	0.1	0	0
Grand Total:	**5.42**	**1.40**	**1.50**

Program/KA	Total FTE
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
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0	0
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0	0
0	0
0	0
0	0
0	0
0	0
0	0
Grand FTE Total:	**0**

Budgets

MRF Funding 2023

Description	Dollars	FTE
Salaries	34000.00	0.83
Fringe Benefits	14620.00	0.00
Wages	0.00	0.00
Travel	70500.00	0.00
Supplies	0.00	0.00
Maintenance	0.00	0.00
Equipment / Capital Improvement	0.00	0.00
Other	4000.00	0.00
Totals	**123120**	**0.83**

Comments

MRF Funding 2024

Description	Dollars	FTE
Salaries	34000.00	0.83
Fringe Benefits	14620.00	0.00
Wages	0.00	0.00
Travel	70500.00	0.00
Supplies	0.00	0.00
Maintenance	0.00	0.00
Equipment / Capital Improvement	0.00	0.00
Other	4000.00	0.00
Totals	**123120**	**0.83**

Comments

MRF Funding 2025

Description	Dollars	FTE
Salaries	34000.00	0.83
Fringe Benefits	14620.00	0.00
Wages	0.00	0.00
Travel	70500.00	0.00
Supplies	0.00	0.00
Maintenance	0.00	0.00
Equipment / Capital Improvement	0.00	0.00
Other	4000.00	0.00
Totals	**123120**	**0.83**

Comments

MRF Funding 2026

Description	Dollars	FTE
Salaries	34000.00	0.83
Fringe Benefits	14620.00	0.00
Wages	0.00	0.00
Travel	84500.00	0.00
Supplies	0.00	0.00
Maintenance	0.00	0.00
Equipment / Capital Improvement	0.00	0.00
Other	9000.00	0.00
Totals	**142120**	**0.83**

Comments

MRF Funding 2027

Description	Dollars	FTE
Salaries	34000.00	0.83
Fringe Benefits	14620.00	0.00
Wages	0.00	0.00
Travel	30500.00	0.00
Supplies	0.00	0.00
Maintenance	0.00	0.00
Equipment / Capital Improvement	0.00	0.00
Other	9000.00	0.00
Totals	**88120**	**0.83**

Comments

Reviewer 1

1.1. Clearly, the three specific objectives to address these gaps are very broad and provide a daunting challenge to provide measurable progress as described. It is therefore very important that the proposal addresses some specific areas that will have measurable and functional outcomes.

Response: We agree that these aims are necessarily broad, but we do have very specific activities planned, and these activities were selected to focus on tasks that (i) support research needs; (ii) require national co-ordination; and (iii) could not reasonably be funded by existing competitive funding sources. Since the NIMSS section to describe the specific activities and outcomes is limited to 4,000 characters, we have instead expanded on these activities and functional outcomes in the initial section where the specific aims are outlined (*Part B. How does this NRSP pertain as a national issue, Section 2. Continued national need for animal genomics capacity.*)

1.2. The second main point of importance is that this proposal is really focused on developing linkages between academic fields of study and those between scientists in the public sector and scientists and business leaders in the private sector (public-private partnerships). These relationships needed to be funded more strategically, especially if the private sector truly recognizes the value of NRSP-8 as stated in the letters of support.

Response: Thank you for raising this point. We hope that the additional information provided for point 1.1 (above) explains how we will strategically develop these linkages between project members and the stakeholders. Specifically, the inserted text indicates that this project does not seek to solve all identified gaps for stakeholders but rather to define them and identify work that can be done through existing competitive funding programs.

1.3. The main point is that this proposal is requesting funding for travel, salaries, and publications. It seems this funding is just to help complement an overall larger effort, where the connection is not directly defined. The actual amount of work needed to make progress on the objectives is daunting based on this funding. Salary requests are truly minimal for the potential amount of work (the people getting the funds need to be overachievers!).

Response: After discussion with USDA AAs, we appreciate that this NRSP proposal should be very specifically focused on activities which support research and that cannot be done either individually, or by other funding mechanisms (e.g., competitive funding opportunities). With this in mind, we have selected activities that complement a larger effort which will be supported by these other revenue streams (e.g., ongoing and novel research programs supported by federal and foundation funding and by funded public-private partnerships). Therefore, the amount of funding requested for this proposal falls in the range stipulated by our USDA AAs.

1.4. Overall – on travel, it seems logical that the funding should be allocated more strategically on the students versus the private sector, if strong initial linkages are to be established between academic fields. (Example could be to spend the travel on nominated and driven students looking to cross-pollinate at meetings - genome scientists going to ASAS and animal scientist students going to PAG and AGBT). It seems reasonable that

private sector EAB members should pay their own way, if the NRSP-8 is truly valuable to their for-profit activities (see LoS) then company leadership should support such networking travel. They could even provide funding as matching funds, and then have it disbursed back if this helps them justify the travel from a financial perspective. Not sure if this can be implemented, but it better leverages public funds.

Response: We agree that this would be the ideal use of funds and anticipate that our industry partners will be able to support their own travel and perhaps willing to support additional travel opportunities for students. Should this proposal be funded we will make this request, however at this stage we need to include this travel in our budget to ensure that our industry partners are represented in key activities for this project and some of these costs are represented in the *Budget and Budget Narrative Additional sources of funding* section.

1.5. The proposal must detail the travel more clearly! It is not clear how many trips are being budgeted within either the multi-state funding or the additional funding. Please just write out the math that allowed you to derive this number (multiple of the expected itemized costs). This is the expected standard for any proposal. There should be a chronogram showing the timing of the meetings and expected venues for maximum impact along with timing of the publications. Even if the plan is latered later, it is better than nothing.

Response: We have added more information about how travel costs were calculated in the budget (see 2. Budget and Budget Narrative, OTT Multistate Research Funding requested). A timeline of activities has also been included (see Figure 2).

1.6. Clearly identified sponsoring beneficiary stakeholders - The stakeholders are described in the proposal on page 6 and 7. Are the stakeholder targets correctly identified? – One could strongly argue that they are not completely described or targeted for maximum impact. Examples - A teaming up of scientists involved in new phenotype capture techniques often reside within animal pharma companies (i.e. Zoetis, Merck, etc.). Pharma has been acquiring technology to better identify sick animal phenotypes, but in some cases, these vet lead efforts have no intent to overlap this with genomics (except maybe within Zoetis). Groups like this are places where genomic resources can be used to create new discovery platforms by partnerships. So as important as moving genomics into traditional animal science may be, the most important traits for food animals are in animal health where genomic approaches between private-public partnerships could be impactful in elucidating the discover and function of genes and effects of their variants on performance and health of our food animals.

Response: Our strategy for identifying stakeholders was based upon inclusiveness, as this was considered essential for a capacity grant with the goals of supporting bioinformatics across a diverse range of scientists and for building public-private sector collaborations. This means that the stakeholder categories are broadly defined, or perhaps that the stakeholder group is not targeted. However, our experience is that (at least initially) a more targeted approach risks missing opportunities or discouraging stakeholders who would otherwise be interested in collaborating. We appreciate your suggestion of teaming up of scientists involved in new phenotype capture techniques and this is the group that we intended to capture in the *Bioinformatic and data scientists group*; the text of this section has been edited to include this information. Likewise, we have included more specific examples in the *Animal science*

researchers section in part B Relevance to Stakeholders. This information is already expanded in the section *A. Priority Established by ESS.*

1.7. There is no beef representation in the LoS, even though one could easily argue that a large share of funding has been spent on bovine genomics by all USDA agencies. From some informal polling, a few prominent progressive breeders ranking in the top 10 for seedstock production don't know about NRSP8 and its impact on their genomic-based breeding. These breeders are active in BIF and are interested in leveraging genomics to better understand feed efficiency, carbon footprint, and better health in performance production. So, a lot of opportunities in this sector, which is mostly ignored by this proposal. Suggest changing or adding NCBA-Cattlemen's College and NSIF (swine – poultry) to the venues to attend for extension to animal breeders.

Response: Included among the letters of support are five letters from industry stakeholders related to beef and dairy, in addition to three letters from genetics companies that use genetics data from multiple species, including bovine genetics. We agree that not all breeders know about the NRSP-8 project and one of the major objectives of this project is to develop more linkages with these stakeholder groups. We thank you for your suggestion to add NCBA and NSIF as possible for Extension and outreach activities and section *B. Management, Budget, and Business Plan, Planned Collaborations & Outreach* has been edited to include these options.

1.8. Other opportunities at these venues - there are many new phenotype device vendors at NCBA, which could lead to new linkages for developing the outreach network. Also, please define the group "animal breeder". Are these the CSO, CTO, and other geneticists in large multi-national companies?

Response: Again, we thank you for your suggestion. Our members' knowledge of companies developing phenotyping devices and strategies will be required to develop these linkages between private and public sectors. We have noted your suggestion and, if funded, will plan to have our initial events at forums like this to best utilized potential new stakeholder opportunities. Our definition of "animal breeder" was deliberately designed to be broad so that we could include CSO, CTO, and other geneticists in large multi-national companies, as you point out. This information has been added to section *B. Relevance to stakeholders: Stakeholders and their needs*.

1.9. Half the proposal is justification, which leaves little space for actually articulating the initiatives in detail for specific milestones that will allow for the measures of progress towards meeting the three objectives of this proposal. From the current text, it is very difficult to specifically understand scenarios of how the objectives will be met.

Response: The criteria for completing a NRSP Capacity proposal requires the completion of sections outlining how the proposal is consistent with the NRSP mission, the national scope of the project and how it fits with the priorities established by ESS, and these sections are lengthy. Within these limits we have worked to include additional information about the activities for this proposal (see our response to review points 1.1 & 1.5).

1.10. Data scientist is a jargon phrase that could mean anything - it should be made more specific.

Response: We have replaced usage of the term 'data scientist' with more specific phrases (e.g. informatics, engineering).

1.11. This assertion of impact was articulated several times (During that same 4-year period, NRSP-8 members produced 924 publications and obtained over $43 million in competitive funding - a return on investment of more than $20 for every dollar provided to the NRSP-8 project). What is the proof that this is a real impact? Would every NRSP-8 member say, "without NRSP-8 funding, I couldn't have written my paper or received my grant?" I think this calculation is overstated and a super simplification of impact that is not accurate. Suggest it to be presented as more of a shared benefit that impacted a certain number of papers.

Response: These figures are based upon impact statements from NRSP-8 annual reports and are cited in the *B. Relevance to stakeholders, 2. Renewal Justification* and *Business Plan, Rationale for Modest and Sustained Support* sections. In both sections it is noted that these figures refer to the productivity of NRSP-8 members; in both cases we have added text to indicate that this is an indirect measure of impact). While we agree that these metrics are a simplification of the impact of genomics research upon animal industries, it is not clear how else the impact of NRSP-8 should be measured. However, we do note that NRSP-8 has been described as a successful project by multiple USDA administrators and that it is the co-ordination activities of the NRSP-8 program that enabled the initial genome sequencing projects, the subsequent development of genomic-based tools (e.g., SNP chips) and – most recently – enabled the community to participate in the AG2PI initiative.

1.12. The genome citations only track up to 2017, so what happened from 2017 to 2022? Did the NRSP-8 contribute to the haplotype-based third-gen genomes coming from cattle? Just an observation - Curious why USMARC is not part of the membership, because they clearly demonstrate leadership in next gen genomes and pan genome work in cattle. How is this interface?

Response: Dr. Tim Smith from USDA MARC and Dr. Ben Rosen from USDA BARC are active participants in NRSP8 activities and have led the haplotype based third generation genomes from cattle and the pangenome initiatives. However, the online membership directory does not currently reflect their status as NRSP-8 members. NRSP-8 contributions towards both the haplotype based third generation genomes and pangenome efforts include both financial support and scientific expertise. Furthermore, contributions have come from the cattle coordinator committee, of which Ben Rosen is a member and from members of the greater NRSP8 community

1.13. Stakeholder involvement in project development, project activities, review, and/or management plans - So the EAB is limited to 5 members. How do these 5 members represent the entire industry using NRSP-8 supported outputs and extension? There should be a higher-level mechanism in the org chart for EAB to provide input from the entire industry, so how does the EAB get this input?

Response: Thank you for this suggestion, we have increased the EAB to 7 people to better represent the industry groups more effectively (aquaculture, beef cattle/dairy, equine, swine, poultry, and ovine/ruminants) and to include a seventh member that could represent either Extension or informaticians/engineers working on phenotype development. We have added this information to the *Business Plan: External Advisory Board (EAB)* section of the proposal. By having the EAB positions filled by industry representatives we anticipate direct feedback from

industry stakeholders and we will also engage other industry members through our industry-focused roundtable discussions and activities described in *Part B. How does this NRSP pertain as a national issue, Section 2. Continued national need for animal genomics capacity.*

1.14. Overall, the program should be only focused on food animals. Politically, horses have been included with food animals even though they are companion animals; so it is hard to understand why they are still diluting the funding stream for any food animal programs in NRSP. They should not be on the EAB.

Response: We respectfully disagree. The USDA has historically considered horses an agriculturally important species and development of genomics capacity is very often species-agnostic so that bioinformatic analyses developed for equine applications are readily adapted for food animals.

1.15. Don't overstate impact – example in the very beginning are: Genome-enabled technologies "co-developed" under NRSP-8 are……by "helping" deliver complete genome sequences of seven agricultural animal species and corresponding genetic tools and resources that…

Response: These changes have been made in the text.

1.16. Overall technical merit (sound scientific approach, achievable objectives, review, and/or management plans) - this is a complex endeavor and it's been at least 5-10 years of genomic resources available to the industry, veterinarians, and animal scientists and still the uptake on the later two fields has been limited. The opportunities are there to really establish linkages for extension to capacity building, it would just be more clear of how to do this with a better described plan of the use of funds to create better capacity building opportunities.

Response: We agree that the uptake of genomics-enabled tools has been limited and that there are opportunities to improve this by developing linkages for extension of this capacity building. Additional information about the activities for this proposal (see our response to review points 1.1 & 1.5).

Reviewer 2

2.1 The proposal would benefit from adding details on where the current large-scale "omics" and "genetics" data are stored (databases), what level of integration exists for this data, how accessible they really are to scientists, and how this project will use them.

Response: This answer to this is complex and multilayered (depending on the data type and research group); ensuring that stakeholders can answer these questions is part of the data management and data re-use workshops we propose to do as part of Aim 1. In the best case scenario large scale data sets are stored in public data repositories, and are brought into databases and resources where they can be integrated around a theme (e.g., expression atlases or pangenomes) for use by a broader range of animal scientists. However, the reviewer has rightly indicated that accessibility to scientists remains a problem which we hypothesize is based upon lack of either knowledge or support for data management best practices. To make genomics more accessible to a broader range of scientists we intend to have discussions with stakeholders about the barriers to analyzing, storing, sharing, re-using and archiving these data sets so that we are able to improve data management. More detail about these activities has been added to the proposal.

Reviewer 3

3.1. However, as this group moves from genetics to phonemics, especially considering high-throughput phonemics, this proposal would be greatly strengthen by the addition of engineers (biosystems or agricultural engineering, mechanical engineers, computer scientist, and/or electrical engineering). The use of sensors in the livestock, especially in a commercial setting, is a new area. Many of the sensors are under development. In addition, having an engineer to explain the limitation of the sensors and the potential novel uses of sensors would be of tremendous help to this community. The collaboration between animal scientist and engineers could be very powerful - as the engineers may not have the understanding of the animals - but understand the sensors , electronic data collection techniques, and data analysis techniques that the animal scientist may not understand well. The combination of two such diverse fields would lend itself to innovation in science and technology.

Response: Thank you for your suggestion, we agree that the inclusion of computer scientists and engineers will be important to support genome to phenome capacity. We have added text to explicitly include device engineers throughout the proposal and included them as a stakeholder ("Informaticians and engineers" in the *Stakeholders and their needs* section.

3.2. There would be room for an additional objective. 4. Continue developments of novel sensors to collect real time individual animal data for all animal species. Not only would the genetics and phonemics components be strengthened, but additional grant money could be acquired through the collaboration of engineers and animal scientist.

Response: While we agree with the importance of this aim, the limitation to adding a fourth objective is the budget cap. However, we have added information about how this proposal begins to build collaborations with engineers and scientists developing phenotypic devices and utilizing the data from these devices within this proposal (see our response to review points 1.1, 1.5 & 1.6). Moreover, the AG2PI initiative also provides opportunities for similar collaborations between scientists and engineers.

Reviewer 4

4.1. Addressing the NRSP Mission. Note that NRSP-8 did not sequence or fund the sequencing of the genomes of livestock, but it brought together the community who valued having them and worked both together and independently to obtain them - NRSP-8 provided communication, collaboration and coordination at different levels for all of these efforts. As written, it would seem that these were solely NRSP-8 accomplishments, which they were not. By rephrasing to clarify that NRSP-8 coalesced the community that advocated for and developed these resources, additional species can be added, including aquaculture. Also, NRSP-8 members accomplished far more than work towards sequences and other resources, there were many important contributions to basic and applied animal science described in those 900+ publications.

Response: We apologize for this impression and have revised text throughout the proposal to clarify that the NRSP-8 project supported genomics initiatives.

4.2. I recommend connecting to two additional communities:

1) It would be good to connect with the plant genomics community, as does the AG2Pi project. No need to be redundant with that effort, but like all competitive projects it is temporary, it would

be good to recognize the value in this kind of collaboration (which is inherent in PAG - maybe that is all that needs to be said.

2) I don't see a direct connection to Tribal stakeholders, which could benefit from these efforts. This may not be easy but it is important, NIFA has a program leader that leads Tribal programs.

Response: Thank you for these suggestions. We have two plant genomics community groups in the section *Planned Collaborations & Outreach* (the AgBioData Consortium, and NRSP-10 National Database Resources for Crop Genomics, Genetics and Breeding Research) and expect to co-ordinate with them on complementary activities. Like you, we don't see a path for a direct connection to Tribal stakeholders, although we are happy to explore the possibility. We have included text to reference how we may begin the process of reaching out to Tribal stakeholders to explore their needs (see section *Stakeholders and their needs*, Extension Services), and we anticipate this might be a longer-term activity where we could also partner with the NRSP-10 and AgBioData communities working on crops.

4.3. When referencing phenotypes and/or improving production systems it would be good to include food safety.

Response: Thank you for your suggestion, we have specifically referred to food safety scientists within our definition of Animal Science Researchers in the *Stakeholders and their needs* section. We also reference the impact of this project on food safety in the *Priority Established by ESS* section.

4.4. Leadership team. I think having coordination by Aim instead of Species is a great approach, but how are different species represented in the new structure? How are they represented on the EAB if there are only five members to represent beef, dairy, swine, horse, turkey, layers, broilers, goat, sheep, catfish, trout, salmon, oyster, etc...? Seems this group should be larger, but more importantly, how are species represented in the overall organizational structure?

Response: We have increased the EAB to represent the industry groups more effectively - a representative each for aquaculture, beef cattle/dairy, equine, swine, poultry, and ovine/ruminants and an additional member to represent either Extension or informaticians/engineers working on phenotype development (see *Business Plan: External Advisory Board (EAB)* section of the proposal). As NRSP-8 transitions to capacity building we have re-organized the organizational structure to be focused on tasks relevant to all species rather than having species co-ordinators. We note that (while there will always be the need for adaptations to specific species), species-agnostic design of resources from this project facilitates further collaborations and comparative projects that can advance all of animal genomics.

4.5. Outcome Delivery Schedule - it seems industry is not involved until year 3 with the round-tables, if we begin with the end in mind - I suggest moving this activity earlier in the project.

Response: We apologize for this misconception and have added more detail to clarify the proposed activities and a Figure showing the timeline. Some of our early activities include engaging industry stakeholders to ensure we identify their needs for this project.

4.6. AG2PI is funded thru the competitive NIFA program AG2P that was created and authorized by the Farm Bill and funded thru annual appropriations, but AG2Pi is not directly funded by the Farm Bill.

Response: Thank you, we have edited the proposal to correct this information.

4.7. Under stakeholders and their needs, please include a bullet and description for Extension.

Response: Thank you, we have added this point.

4.8. Target audience - please include undergraduates in the second bullet and an additional bullet for Extension

Response: Thank you, we have added this point.

Reviewer 5

5.1. Further clarify the involvement of stakeholders. As written, stakeholders that will be included in various aspects of the work are identified from contact lists taken from traditional genomics scientist and researchers. Input from stakeholders outside this sphere could broaden the support of the proposal, expand the various inputs of the proposal, and add to the applicability of the outputs from the proposal.

Response: We have clarified that our intent is to initially use our membership contacts to reach out to stakeholders to be involved in activities. However, we will also seek out new stakeholder interactions and some of the ways we will do this are (i) having project meetings and workshops at non-genomics themed meetings; (ii) have stakeholder discussion forums; and (iii) reaching out to Extension agents and specialists (who will have additional industry contacts) and to informaticians and engineers working with phenotype data and devices. We have added additional information to the proposal about these activities and revised the stakeholder section to reflect this intent.

5.2. Consider the role of Extension. The land-grant university system is mentioned in Planned Collaborations & Outreach section, and its components are mentioned and alluded to throughout the proposal. However, Extension is not listed/addressed in the Stakeholders & Their Needs section. Additionally, how will Extension, and other stakeholders, be informed of proposal outputs so they can be disseminated to end-user groups.

Response: We apologize for this oversight and have corrected it in the proposal (see also our response to review point 4.7).

5.3. Clarify the management of outputs and access to outputs. As written, it is not completely clear where data sets, outputs, etc. will be housed, how they will, or can be accessed. Also, how will stakeholder groups/users be made aware of the outputs and what methods will be used to notify/inform stakeholders outside of the traditional sphere of users.

Response: The management of outputs and access to outputs are described in section *D. Outreach, Communications, and Assessment* subsection *5. Data management plan*. This section states that - although this project will not directly generate genomics data - it will use this type of data and make access to the products produced available to the community via established public resources and repositories. Moreover, we directly state that other resources developed from this project (e.g., reports, worked examples, publications, etc.) will also be made publicly available. We have not outlined every specific place these resources will be made available because of the diversity of data types and products that will be produced. We have added additional information that the products of this proposal will be available on the project website we will set up.

5.4. Consider the value of the work. What specific steps will be taken to assess and evaluate the outcomes of the proposal. Who will be provided with the assessments and how will future efforts change accordingly?

Response: The details of how we will assess the outcomes of this proposal are outlined in *D. Outreach, Communications, and Assessment*, section 3. *Measuring accomplishments and outcomes*. Assessments include quantitative and qualitative measures of each activity along with expected outcomes. The assessments will be included as part of the project's annual report and distributed to the External Advisory Board, (EAB) project members, stakeholders and our project administrators. These assessments and reports will inform our future directions and activities and project members will discuss how to implement changes based upon EAB and administrator feedback at our annual meetings.

Requested Duration: 10/01/2023 to 09/30/2028

Statement of Issues and Justification:

Prerequisite Criteria

A. How is the NRSP consistent with the mission?

Background. The National Animal Genome Research Program (NAGRP), NRSP-8, has been hugely successful, exceeding all expectations, by helping to deliver complete genome sequences of seven agricultural animal species (pig, cattle, sheep, goat, horse, chicken and turkey) and providing genetic tools and resources that have revolutionized the animal breeding industry. Genome-enabled technologies co-developed under NRSP-8 are now helping to deliver commercial animal breeding and production for many species, resulting in a multifold return on investment to US stakeholders and producers. These successes, along with concomitant advances in genomics-enabled technologies, resulted in the release of the 2018-2027 USDA Animal Genome Blueprint (1) which outlines key areas for future research and funding. A crucial element identified in this report is "Science to Practice", which is the application of genomics-enabled technologies to traits and phenotypes critical to animal industries. The "Science to Practice" goals are undoubtedly attainable, in large part because of the genetic resources and technologies developed through NRSP-8. However, a long-term goal of the NRSP-8 community has been to support the development of tools to link omics data to important animal traits and applications to utilize this information within animal industries.

This proposal leverages the significant accomplishments and products of the NRSP-8 program, but in contrast to previous requests for renewing NRSP-8, the new project will redirect its objectives and focus solely on capacity development. Importantly, we will expand the NRSP-8 community to include direct involvement of additional stakeholders, including non-genomics scientists and researchers, Extension personnel, and animal industry representatives. Moreover, increasing capacity that enables the application of genomics to animal traits and phenotypes will require the development of linkages with informaticians and engineers, expertise that has not to date been a significant part of NRSP-8. Integration of genomics and other biological data types, and more specifically, bioinformatics, which is the management, analysis and sharing of biological data, will link genome data with phenome data in a very deliberate way. Animal industries are increasingly employing data collection technologies in all aspects of production, performance, health and welfare. Examples of applying data science to animal industries include image analysis to investigate tail-biting in pigs (2), Radio Frequency Identification (RFID) for studying cattle grazing behaviors (3), gait analysis of horses using neural network analysis of video data (4) and machine learning algorithms to predict health issues in aquaculture systems (5). Linking these incredibly rich datasets with genomic information and tools will provide new opportunities for US animal agriculture and accomplish the goals of the USDA Animal Genome Blueprint.

The realization of this vision will require the development of enabling capacity that is not covered under current competitive grant programs. In addition, initial conversations that have occurred between NRSP-8 constituents and industry representatives about their industry's specific needs must be continued and expanded, thereby developing knowledge, trust and understanding among the two groups. Key to these conversations are our land grant Extension personnel who are uniquely positioned to deliver new knowledge and applications to animal industries and in the opposite direction, they can ensure that current production issues are at the forefront of research objectives. In addition, novel collaborations of NRSP-8 researchers with informaticians and

agricultural engineers will further develop capacity for integrating new data types into animal agriculture research. Underpinning these efforts, we must ensure that a broad and diverse group of animal researchers, beyond just animal genomicists, are prepared to utilize informatics techniques (including bioinformatics) to support innovation in US animal industries. With this in mind, ***we propose to convert NRSP-8 into a national multi-institutional capacity project that will develop the infrastructure and expertise in order to expand genomics-enabled technologies into US animal industries.***

Supporting the NRSP Mission. The overall goal and specific objectives of this proposal are directly aligned with the mission of the NRSP through development of enabling technologies and by providing training and education that support the application of genomics across the complete range of agricultural animal sciences and species. By bringing together researchers in animal science, genomics and engineering, as well as Extension faculty and industry representatives, we will accomplish what could not be realized by individual efforts or by animal genomicists alone. The opportunity to coordinate discussions and develop collaborations will provide a set of guiding principles and resources which can then be applied to research projects across the country. Moreover, we anticipate that the opportunities provided by multi-disciplinary interactions will create novel Research, Education and Extension links focused around the application of genomics to animal industries.

Supporting State Agricultural Experiment Stations: Land-grant institutions are focused on (1) student-centered education to develop the 21st century workforce (2) delivery of cutting-edge discoveries that advance knowledge in state and national need areas; and (3) providing outreach that educates and elevates individuals, families and communities. This proposal, which focuses on the development of capacity, responds to all three areas. In addition, the application of genomics-enabled technologies ensures that US agriculture remains globally competitive, enhances US food security and safety, supports sustainable production innovation, and provides actionable information that informs regulatory policies.

B. How does this NRSP pertain as a national issue?

National Scope

Livestock and poultry are top US agricultural commodities, accounting for more than half of the agricultural cash receipts and totally at least $100 billion each year. Conversely, the US imports ~90% of its seafood, at a deficit of more than $17 billion per year. Therefore, advances in livestock, poultry and aquaculture production capacity and efficiency are essential for advancing national and global food security, especially with increasing consumer demands for improved animal welfare and reduced chemical interventions, the world's changing climate, and competing allocations of land and water. To enable agri-animal industries to increase production and meet growing demands, we need robust animals with superior health and production traits and optimal management of these animals, while relying to a lesser degree on antimicrobials that can increase the risk of resistant pathogens, especially emergent zoonotic pathogens (6). These challenges cannot be addressed without significant advances in the animal sciences, including nutrition, physiology (reproduction, lactation, growth, ethology, etc.), genetics, and meat science. Scientific efforts must capitalize on the latest advances in technology, including the various fast-developing "omics technologies" (genomics, epigenomics, transcriptomics, proteomics, metabolomics, microbiomics), automated high-throughput phenotyping technologies (sensors, cameras, etc.), and the associated statistical "big data" approaches (e.g., artificial intelligence and machine learning). However, application of these emerging technologies puts additional pressures on the

broader animal science community, including an understand of the various omics technologies and the ability to handle big data. Scientists in animal science disciplines outside of genetics are typically not trained in the use of big data, nor in the various genomics technologies. This results in an opportunity cost, because animal scientists may not fully exploit the freely available genomic tools, resources, and knowledge that would greatly benefit and illuminate their research. Thus, there is a need to enable the use of genomic information across all fields of animal science in both academia and industry. Also, it must be noted that funds available for generating large datasets relevant to animal genomics are extremely limited. Therefore, the re-use and repurposing of existing datasets for gaining insight into novel questions represent opportunities to increase the value of data collection both in time and resources. In short, to fully leverage investments in genomic information, we need to help ***"normalize" the use of genomic information and associated technologies*** and lower the barrier to entry for research groups that are less familiar with genomics resources and tools.

1. Continued national need for animal genomics capacity

In the past three years, there have been several developments that impact the future of animal genomics and its application to livestock production, including release of the *USDA Blueprint for Animal Genome Research*, followed by the 2020 release of the *USDA Agricultural Innovation Agenda* that signaled the intent of USDA to increase US agricultural production by 40%, while cutting its environmental footprint in half by 2050. The *Agricultural Genome to Phenome Initiative* (AG2PI), funded via USDA NIFA, is joint plant and animal effort to prepare research communities to embark on a large-scale effort to link genomes to biological function (phenomes) across crops and animals of importance to the agriculture sector of the US. Also in 2020, EO 13921 *Promoting American Seafood Competitiveness and Economic Growth* detailed the need for improving US competitiveness in the global seafood market. Current NRSP-8 members are an integral part of AG2PI. Moreover, we are also positioned to work collaboratively and synergistically with the crop genomics community to enable the linkage of genomics and predictive phenomics with other available biotechnologies. Supporting capacity development will ensure that investments in genomics are leveraged to generate the best societal and environmental benefits to help USDA meet its goals for US agriculture. *This renewal application builds on the successes of NRSP-8 and provides a logical, sustainable progression to develop and sustain genomics-related capacity.*

We propose a national project that develops capability in using genomics-enabled technologies within diverse animal industries. In this context we define genomics-enabled technologies as any high-throughput platform that relies on genomics-wide data analyses (including transcriptomics, sequencing, proteomics, etc.), global analysis of metabolites, and the microbiome, as well as phenomics and large-scale genetics studies (including GWAS, haplotype analysis, and use of genetic markers, traits, or phenotypes). Developing this very broad capacity requires an infrastructure that supports consistent collection and use of genomics data types, their integration with rich phenotypic (meta) data, and the development of human expertise in bioinformatics and related informatics and engineering techniques. Building both informatics and human capacity will ensure the application of these techniques into predictive biology that supports resilient agricultural systems.

Our overall goal is to develop the infrastructure and expertise required to apply genomics-enabled technologies to US animal industries. This overall goal is supported by three specific objectives:

(1) Extending genomics capacity to a broader range of Animal Science stakeholders. New genomic technologies support the collection of expanded "omic" data types and increasing data volume. In fact, for most researchers, it is now easier to generate genomic

data than it is to manage and analyze the resulting data. Aim 1 specifically addresses the ways researchers can acquire, analyze, share and re-use genomics data types for their own programs.

Summary of approach: Our approach will be to survey stakeholders to identify their needs in genomic analyses and data sharing. The survey results will be used to develop well-documented and easily accessible workflows, as well as community best practices. These topics will be included in "training and education" workshops, along with detailed step-by-step guides and worked examples. Resources developed under this aim will be prioritized based on stakeholder feedback, as it is unlikely that all needs will be addressed in this project (although we anticipate seeking funding from other sources to support additional work). Additionally, unmet gaps gaps will inform potential needs for AFRI Program Directors and SAES supported projects.

Measurable outcomes: Outcomes will be measured by (i) the number of workflows and standards developed and (ii) usage statistics for these resources by the stakeholder community. The *expected impact* of these outcomes is an expansion of capacity for the broader research community in effectively utilizing genomics approaches.

(2) Supporting capacity to integrate genomic and biological data. New engineering technologies are now allowing animal scientists to collect biological data for a wide variety of animal traits and phenotypes. Similar to Aim 1, we now need to develop the ability to manage, analyze and integrate these large and complex biological datasets and then connect them to the genomics information that is also being collected. Aim 2 specifically addresses the need for scientists to integrate diverse data types, both biological measurements and genomics, for a more complete understanding of complex agricultural systems.

Summary of approach: Our approach will provide opportunities for those developing phenotype collection devices, those collecting and analyzing phenotypic data, and those analyzing genomics data to meet and discuss common goals for data and analysis integration. As part of this approach to establish transdisciplinary teams, we will also support students and early career investigators to attend meetings to learn more about interdisciplinary efforts related to this topic.

Measurable outcomes: Outcomes will be measured by (i) new research collaborations developed due to these meetings (measured by grant submissions, publications and reports) and (ii) number of investigators who attend conferences or meetings supported by this initiative. The *expected impact* of these outcomes is a transition from narrowly focused bioinformatics capacity to a much broader application of informatics techniques for animal industries.

(3) Education, training and outreach to develop a data-savvy workforce. The animal genomics community has been relatively successful at providing bioinformatics training that supports genomics studies. However, there is an acute need to extend this capability to the entire animal science community and to ensure that animal scientists can manage and apply the expanding range of data types which are used in animal industries (e.g., genetic, genomic, epigenetic, GIS, images and audio data types). Aim 3 specifically addresses the need for ensuring that we are developing the 21st century agricultural workforce in the areas of informatics science, which can keep US agriculture globally competitive and resilient.

Summary of approach: We will develop a mailing list/bulletin board to publicize internship opportunities between stakeholders, students and academic advisors, and support bioinformatic training workshops at animal science meetings and conferences. To support the industry need for employees with bioinformatics skills we will also develop several bioinformatics themed educational modules which can be used in animal science education and training; these are not meant to be comprehensive, but rather supply proof of concept that can be used for future competitive funding proposals.

Measurable outcomes: Outcomes will be measured by (i) usage statistics of the mailing list and mentor/student surveys; (ii) number of training workshops, attendance and surveys of attendees experience; and (iii) usage statistics for these resources by the community. The *expected impact* of these outcomes is the development of scientists who are able to apply bioinformatics to agriculture.

Rationale:

A. Priority Established by ESS

This proposal supports Grand Challenges identified by the ESCOP Science and Technology Committee (STC) Science Roadmap for Food and Agriculture (2020) as outlined below.

Grand Challenge 1: Enhancing the sustainability, competitiveness, and profitability of US food and agricultural systems. Developing capacity that links genomics technologies with key production, performance and welfare phenotypes will address this grand challenge by:

- maximizing capacity to enhance animal production and performance using genomics and developing new animal breeds and stocks to support diverse and resilient agricultural systems;
- applying technologies to improve animal health, well-being, and welfare in all production systems;
- enhancing nutrition efficiency and sustainability, productivity, and quality of food products in agricultural systems; and
- improving technologies for animal waste utilization and management to reduce the environmental impact of agricultural production systems.

Moreover, these outcomes also directly align with USDA Strategic Plan (7) Strategic Goal 2 (*Ensure America's Agricultural System is Equitable, Resilient, and Prosperous*), particularly by protecting animal health and fostering agricultural innovation.

Grand Challenge 2: Adapting to and mitigating the impacts of climate change on food, feed, fiber, and fuel systems in the United States. Developing capacity to apply omics technologies to animal industries supports this grand challenge by:

- applying precision agriculture for developing resilient animal lines and breeds adapted to local and to changing conditions;
- developing and sharing new, rapid breeding technologies to effectively respond to emergent vulnerabilities as microclimates become suitable for previously non-threatening diseases and pests and freshwater resources become limited;
- generating new livestock models focused on heat stress and greenhouse gas mitigation in livestock facilities; and

- acquiring and sharing accessible phenotypic data to support decision systems that integrate animal management with changing climate forecasts.

These outcomes also directly align with USDA Strategic Plan (7) Strategic Goal 1 (*Combat Climate Change to Support America's Working Lands, Natural Resources*) by building capacity to adapt to the consequences of climate change and reducing greenhouse emissions.

Grand Challenge 3: Supporting energy security and the development of the bioeconomy from renewable natural resources in the US. The integration of animal genetics with phenotypes plays an important role in the US bioeconomy (8). Examples of how the capacity developed under this proposal will support this grand challenge include:

- continuing development of sustainable animal-sourced food products;
- developing animal-based bio-economies to support the revitalization of rural areas;
- identifying and preserving biodiversity of animal-based bio-economies; and
- developing and sharing information to support innovative systems for reducing, recycling or reusing agricultural waste.

Grand Challenge 4: Ensuring a safe, secure, and abundant food supply for the US and the world. Developing capacity to apply omics technologies to animal industries supports this grand challenge via:

- increased information about optimal management strategies for reducing bioactive compounds such as antibiotics and pharmaceuticals;
- information that informs effective food production regulatory policies by the USDA, FDA, Environmental Protection Agency (EPA), and other federal agencies;
- support for technologies that maximize the genomic potential of animals for enhanced productivity and quality;
- creation of novel breeding programs that balance and optimized nutritional value with production characteristics;
- improved ability to study host tolerance and host/pathogen interactions (e.g., Salmonella);
- development of direct collaborative links between research institutions and industry to promote the translation of new knowledge into practical applications; and
- mechanisms for cooperative international initiatives that globally enhance food safety, security, and abundance.

In addition, these outcomes support USDA Strategic Plan (7) Strategic Goal 4 (*Provide All Americans Safe, Nutritious Food*), in particular preventing foodborne illness and protecting public health.

Grand Challenge 5: Improving human health, nutrition, and wellness of the US population. Developing capacity for omics technologies combined with the ability to capture key industry phenotypes will support this challenge in the following ways:

- develop animal food products with enhanced nutrition;
- enhance the use of animal models in human medicine; and
- support the use of animal-assisted therapies in human rehabilitation and wellness.

Grand Challenge 6: Heightening environmental stewardship through the development of sustainable management practices. The capacity developed by this proposal underpins innovations that can support:

- sustainable feeding and pest management strategies for livestock production systems;
- mitigation of methane emission from ruminants through combined genetic-dietary approaches;
- enhanced feeding practices to reduce nitrogen waste from livestock systems;
- support for precision agriculture approached to reduce chemical/antibiotic use and waste runoff;
- information to increase our understanding of ecological interactions that occur in animal industries; and
- advanced production of fish, shellfish, and aquatic plants in aquaculture systems through application of omics technologies and advanced selective breeding and domestication.

In addition to its alignment with the ESCOP STC Grand Challenges and the USDA Strategic Plan (2022-2026), the objectives of this proposal align directly with the USDA Blueprint for Animal Genome Research (1). This report highlighted progress towards assembling genomes for agriculturally relevant animals and identifying genomic and sequence variants. The report also provided examples of how these techniques and knowledge had been applied to animal industries. However, the report notes that "understanding these genomic effects is now limited by the phenotypes that are collected". Finally, the 2021 Threats to Food and Agricultural Resources report released by the US DHS and ODNI Analytic Exchange Program outlined grand challenges to US food security (9) including: "*The US government should lead research coordination of public-private partnerships for [agricultural] information sharing standards and risk mitigation*" and "*The US government needs to promote domestic aquaculture for food production*".

In sum, the goal of this proposal is to make genomic techniques and knowledge widely accessible to a broad range of researchers and stakeholders and to co-ordinate research opportunities between animal scientists, informaticians and agricultural engineers developing phenomic data collection. These opportunities will support the extended use of genomics technologies and ensure their integration with phenotypic initiatives. These actions will significantly increase national food animal production capabilities.

B. Relevance to stakeholders

1. Stakeholders and their needs

Stakeholders will be included in this project based on their ability and commitment to enhancing the application of genomics into the animal industries. These groups are:

- Animal science researchers: This proposal supports the development of genomics expertise that will lower barriers for a broad group of researchers (e.g., animal health, food safety, reproduction, etc.) so they can effectively apply genomics to their research.
- Future animal scientists: This proposal will provide education and training opportunities for animal science students, as well as develop links with industry stakeholders who can provide internship placements and support novel collaborations for the students.
- Breed associations: An important goal of this proposal is to engage with representatives of breed associations to identify their needs and to ensure that they can access and apply resources, tools and expertise developed by this proposal.
- Animal breeders: We will continue to support the needs of animal breeders by developing shared cyberinfrastructure and providing training opportunities. This includes CSO, CTO, and other geneticists in large multi-national companies.

- Informaticians: Many bioinformatics trained personnel are already involved in the NRSP-8 project. By including a broader group of informaticians, especially those using large dataset of phenotype data, we will support the development of data science capacity specifically for animal agriculture and connect/engage with informaticians who are interested in working on agricultural systems but to date have not been involved.
- Engineers: Emerging areas of engineering are developing devices, such as sensors and nanotechnology assays, that can be used for collecting measurements on large numbers of animals and/or used for highly refined measurements (such as movement, heat, biochemical indicators, etc.). Collaborations across the project will lead to new measurements (i.e. phenotypes) that can then be analyzed for genetic involvement or control.
- Regulatory and policy offices: This project will develop capacity which helps federal agencies to apply evidence-based science and informs decision making for new policies. Well-designed and achievable polices and regulations are critical components in the application of genomics to animal industries.
- USDA directors and managers: Discussions with all stakeholders are expected to identify emerging industry needs. We will continue to work closely with USDA administration, including AFRI program managers, to develop RFPs and white papers that advance research in the needed areas.
- Extension staff: Extension personnel are often the first line of communication with animal producers who would like to apply genomics in their production systems. This project will provide up-to-date information, education, and connections to Extension professionals, who can then transfer that knowledge to industry people who want to use genomics or genomic evaluation but don't know how to start. The inclusion of Extension staff in the project will also greatly expand the project's reach because of their connections with agriculture animal stakeholders who do not have direct connection with project members, such as small-scale producers and faculty at Tribal institutions.
- Animal science undergraduate and graduate students: This proposal provides educational and mentoring activities for undergraduate and graduate students, including support to attend scientific and stakeholder meetings.

As the capacity for applying genomics-enabled technologies to US animal industries increases, we anticipate that additional stakeholder groups will be added to the project (e.g., opportunities to work with Tribal communities). Furthermore, we acknowledge that the ultimate stakeholders of this NRSP are consumers and US taxpayers. Members of this project will strive to engage diverse sectors and communities to increase awareness and knowledge of genomics and its contribution in ensuring the sustainability of US animal agriculture.

Involving stakeholders in this proposal: As detailed in the business plan, stakeholders will be engaged in multiple aspects of this project, including key decision-making processes. First, we will establish an External Advisory Board (EAB) of industry stakeholders to ensure that project activities are focused on industry needs, and the NRSP leadership will meet at least annually with the EAB. Second, we will use the existing AnGenMap and other professional mailing lists to encourage broad participation by all stakeholders, including animal scientists, breeders, Extension personnel, and educators. Third, many of the bioinformaticians involved in NRSP-8 have contacts in informatics and related engineering fields, including public data resources, databases and cyber-infrastructure platforms, as well as through professional associations. These relationships will be leveraged to support this NRSP, as well as to the broader informatics and engineering community, through targeted workshops and training events. This last approach will have the additional benefit of increasing awareness of opportunities for data scientists within

animal agriculture. Details of how the stakeholders will be involved in this NRSP are further elaborated in the Business Plan and Integration sections.

Assessing stakeholder use of outcomes: Our assessment of stakeholder engagement with activities and resources will include quantitative and qualitative pre- and post- measures. Examples of assessment metrics include:

- Attendance of stakeholders at NRSP events and workshops
- Event and workshop satisfaction assessments
- Responses to project surveys on developing capacity
- Engagement on the project website and mailing list
- Resources developed by members of this project and their access/use metrics
- Research products that cite the use of resources and expertise developed under this project
- Collaborative links between NRSP members and with non-members
- Students attending education events and their assessment of learning goals for these events
- Internship and training opportunities supported by NRSP members and industry stakeholders.

Assessment of NSRP outcomes will be included as part of each activity. The outcomes will be reviewed annually by project members and stakeholders to ensure we continue to meet our objectives and effectively engage stakeholder groups. We anticipate that review of project outcomes and stakeholder involvement will require us to adapt to changing circumstances and emerging research objectives as the project progresses.

Contribution to public policy: Project outcomes will include resources and information that support the application of genomics to animal industries. Making genomics data more accessible and the associated analyses more reproducible will aid in development of or contribute to the discussion of public policy related to food safety, environmental protection and understanding the impacts of genetically modified animals. By increasing capacity that enables a wider range of agricultural scientists to apply genomic technologies, we broaden participation and scientific expertise that address key challenges in animal industries such as reducing the use of antibiotics in production systems, identifying approaches for animal waste utilization, improved animal health and welfare, and understanding the mechanisms and effects of genetic modifications both on animals and their production environment. US regulatory agencies will be able to utilize detailed information about the molecular basis of complex biological systems, which supports the application of evidence-based science for policy development. We will include representatives from key regulatory agencies in NRSP discussions and activities so that a diverse group of stakeholder voices are incorporated during the early stages of the project as well as in the planning of subsequent resources and directions.

2. Renewal Justification

This capacity proposal directly supports and extends the genomics “capacity” developed under NRSP-8, which currently has 105 members from 49 institutes. Members span 36 US states and seven countries, making it truly a national project with international collaborators. From 2018-2021, NRSP-8 was supported by OTT Multi-state Research Funding at $500,000 per year. As an indirect measure of impact, during that same 4-year period, NRSP-8 members produced 924 publications and obtained over $43 million in competitive funding - a return on investment of more than $20 for every dollar provided to the NRSP-8 project. Embedded within the NRSP-8

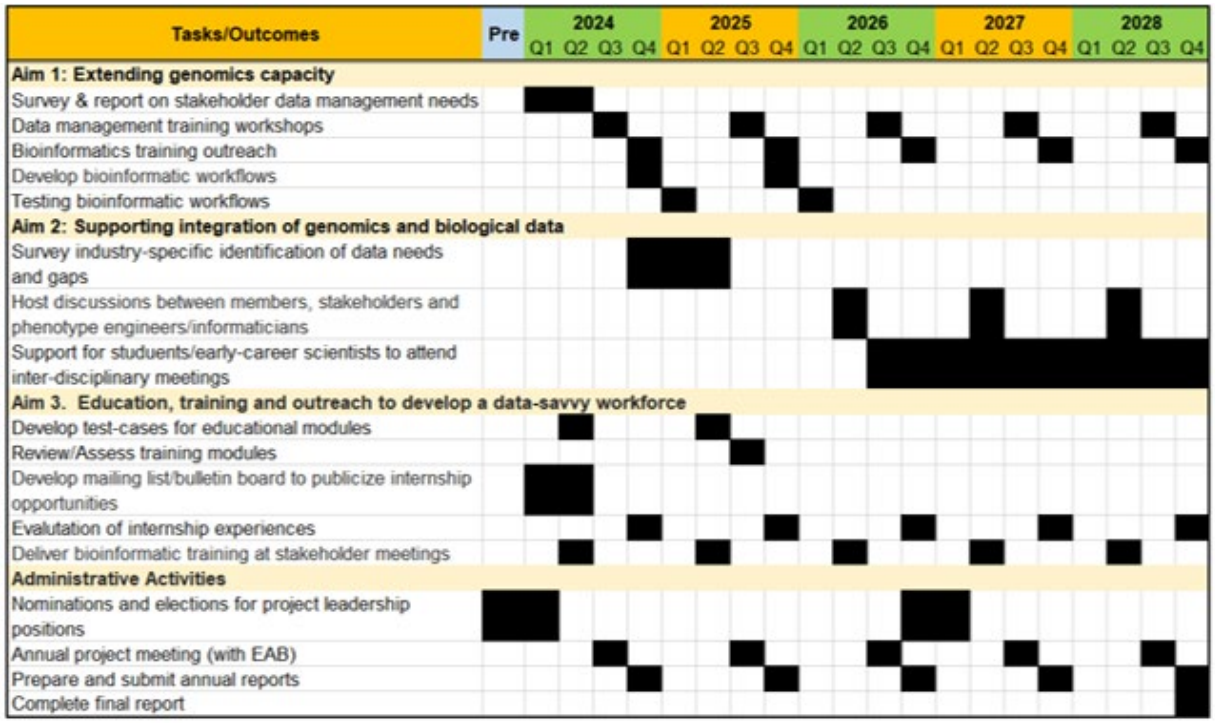
publications are descriptions of deep and impressive outcomes and impacts within animal agriculture, such as significant genetic gains due to genomic selection; identification of specific genetic variants that are associated with traits and measurements of economic importance; improved understanding of genetic control of biological systems; novel approaches for genetic selection; etc. The annual NRSP-8 reports are filled within these types of impacts. However, *much more can be accomplished if the use and application of genomics resources developed under NRSP-8 are applied even more broadly*. Therefore, this project has been designed to expand the application of genomic technologies across all animal science research areas. Training, education and collaborations of researchers and stakeholders outside the field of genomics will broaden the use of agricultural animal genomics resources and analytical approaches that have been developed within the NRSP-8 project.

Over the last four years, NRSP-8 members have held meetings with industry stakeholders to gauge the application of genomics in their companies and production systems. Industry representatives have made it clear they want continued access to bioinformatics resources, expanded bioinformatics training, opportunities to recruit data-savvy graduates, and the ability to link genetics data with information they are collecting on animal traits and phenotypes within their operations. Thus, this new NRSP proposal will have a concentrated emphasis on animal industry needs. In demonstration of this emphasis, letters of support from industry stakeholders are included in the proposal.

Implementation:

A. Objectives and Projected Outcomes

The aims of this proposal are focused on developing informatics capacity to meet a variety of stakeholder needs (see previous sections). Also, accomplishments and productivity of the previous NRSP-8 project are discussed in the previous section. Figure 1 shows the timing of these activities.



Specific Aim 1: Extending genomics capacity to a broader range of Animal Science stakeholders.

Approach:

- survey stakeholders on data capacity needs;
- design workflows to simplify data sharing;
- develop resources (e.g., protocols.io) for genomic workflows;
- support community use of micropublications that ensure datasets are publicly available and citable; and
- generate community benchmarks for data analysis and re-use.

Specific Aim 2: Supporting capacity to integrate genomic and biological data.

Approach:

- workshops to identify stakeholder data collection and data analysis gaps;
- roundtable discussions with informaticians and engineers to develop interdisciplinary teams; and
- support for students and early career investigators, including attendance at bioinformatics and data science meetings.

Specific Aim 3: Education, training and outreach to develop a data-savvy workforce.

Approach:

- development and publication of stand-alone educational modules that can be added to existing animal science courses or used as stand-alone training;
- linking educational modules with micro-certificates that signal data competencies;
- development of a mailing list/bulletin board to publicize internship opportunities between stakeholders, students and academic advisors in animal science; and
- bioinformatics training workshops at meetings and conferences.

B. Expected Outcomes and Impacts

Outputs:

Published report on the data management capacity needs of stakeholders. Expected impact: Knowledge to support the application of precision genomics in animal industries.

Coordination of resources to facilitate data deposition and re-use. Expected impact: Support for data sharing and re-use to accelerate the use of omics technologies and ensure a return on investment.

Evaluation and standardization of methods for recognition of data reuse. Expected impact: Capacity for the broader research community to effectively utilize genomics approaches.

Exchange of ideas to identify key data collection and management needs of stakeholders. Expected impact: Development of knowledge, resources and interdisciplinary teams that can address the Grand Challenges facing agriculture.

Published report of animal industry needs for integrating genomics and other data types. Expected impact: Capacity for precision agriculture in animal industries.

Identification of future stakeholder needs integrating genomics data. Expected impact: Support for the development of sustainable, resilient and economically viable animal industries in a changing environment.

Exchange of ideas and expertise with informaticians and engineering experts. Expected impact: New collaborations between scientists of diverse research areas to develop capacity for phenomics.

Support for students and early career investigators to attend informatics and phenotyping meetings. Expected impact: Development of a data-literate animal agriculture workforce.

Coordination of undergraduate and graduate student educational resources. Expected impact: Development of a data-literate animal agriculture workforce.

Identification and coordination of information about internship programs for animal science students. Expected impact: Preparation of a new generation of data-savvy scientists for the agricultural workforce.

Coordination to develop animal science relevant training. Expected impact: Opportunities for continued professional development for the animal industry workforce and partnerships between industry and academia.

B. Management, Budget, and Business Plan:

1. Business Plan

Rationale for Modest and Sustained Support: In the last renewal period, NRSP-8 received $500,000 per year from SAES which was distributed across six species coordinators (pig, cattle, sheep/goat, horse, poultry and aquaculture at $65K per coordinator) and a bioinformatics coordinator ($110K). As an indirect measure of impact, members of the NRSP-8 project have been highly productive, attributing 924 publications and more than $43 million in competitive grant and contract funding to NRSP-8 from 2018 to 2021. However, the broader and more lasting outputs of the NRSP-8 project are the genomics resources and tools that were developed since the inception of NRSP-8 in 1993. These tremendous outputs will now be leveraged to future genomic discoveries in farm animal species under the new proposed project, while expanding capacity to a much broader stakeholder community. The new NRSP project's business management plan is designed to ensure that the project will function smoothly and effectively and will maximize opportunities to seek funding beyond the OTT MRF. Modest annual funding ($127,120) is requested for the first three years of the project.

Organizational Structure: An outline of the organizational structure for this project is shown in Figure 2 and indicates interaction among stakeholders, NRSP leadership and NRSP members.

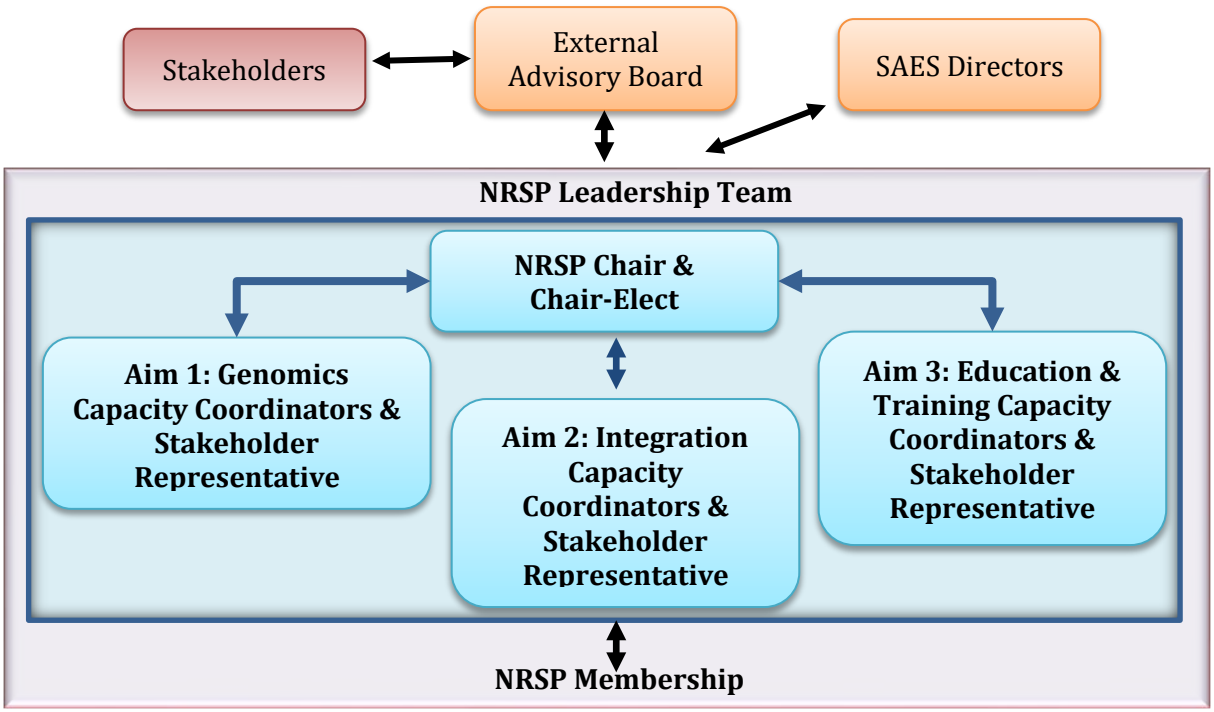


Figure 2. Organizational structure for NRSP project management.

Briefly, the NRSP Leadership Team will include a Chair, a Chair-Elect, and three additional individuals under each of the three aims: a Coordinator, a Coordinator-Elect, and a Stakeholder Representative. Thus, the Leadership Team will include 11 members who will collaboratively organize the annual meetings, where the full membership will discuss, prioritize and develop strategies for meeting the project's aims and outcomes. The Leadership Team will also organize and collate annual reports to SAES Directors and an External Advisory Board (EAB).

NRSP Leadership Team:

- Chair (NRSP member, elected by NRSP members): manage overall logistics of the project including the annual meeting, development of annual reports, and disseminating the annual report to the project members, the External Advisory Board, and the SAES Directors. The chair will serve a two-year term.
- Chair-Elect (NRSP member, elected by NRSP members): assist Chair with project responsibilities. The Chair-Elect will serve a two-year term and then move into the position of Chair after the Chair's two-year term is completed. A new Chair-Elect will then be elected by the NRSP membership.
- Coordinators for each aim (NRSP member, elected by NRSP members): manage activities for their respective specific aim and report on these activities and their outcomes at the annual meetings. The coordinators will serve a two-year term.
- Coordinator-Elects for each aim (NRSP member, elected by NRSP members): assist with Coordinator responsibilities and ensure activities meet stakeholder needs. The Coordinator-Elect will serve a two-year term and then move into the position of

Coordinator after the Coordinator's two-year term is completed. A new Coordinator-Elect will then be elected by the NRSP membership.

- Stakeholder Representatives for each aim (not required to be an NRSP member, nominated by NRSP members, reviewed and selected by the NRSP chair, chair-elect, coordinators and coordinator-elects): assist with connecting stakeholders (animal breeding companies, breed associations, Extension staff, USDA administrators, etc.) to the project. Stakeholder Representatives will ideally be selected from Extension, industry, and other stakeholder groups and will serve for two-year terms. These representatives can serve a second consecutive term based on the level of their activity and commitment to the project, as assessed by the elected Leadership Team members.

External Advisory Board (EAB): The EAB will consist of industry professionals engaged with agricultural animal species (aquaculture, beef cattle, dairy cattle, equine, swine, poultry, sheep and goats), as well as an Extension professional, an informatician who is directly involved in analyzing large datasets of phenotypes, and an agricultural engineer who is developing new approaches to measuring animal phenotypes. NRSP members will nominate individuals for the External Advisory Board; final selection of Board members will be determined by the NRSP Leadership Team. Members of the EAB will serve two-year terms and their position on the Board will be renewed based on the level of activity and commitment to the project, as assessed by the Leadership Team. The EAB will be expected to review the annual progress reports and provide the NRSP Leadership Team with feedback on project progress and activities, stakeholder needs, and the impact of capacity developed within the project, which will be shared with the full membership. There is also the expectation that the EAB will attend at least part of the project annual meeting.

Nominations for the elected NRSP Leadership Team positions (chair, chair-elect, coordinators and coordinator-elects) will be sought from the project membership so that there is broad representation of technical expertise, stage-of-career, and institutional geography. These nominations will be presented in an election available to all NRSP members. Nominations for the Stakeholder Representatives and the External Advisory Board will be sought so that there is broad representation across the various stakeholder groups listed in Section B.1 above. Final selection of the Stakeholder Representatives will be determined by the elected NRSP Leadership Team whereas final selection of the EAB members will be determined by the full NRSP Leadership Team, including the Stakeholder Representatives.

In anticipation of a successful project approval, which should be determined by September 2023, those individuals who are interested in joining the new project have been asked to submit an Appendix E through nimss.org under NRSP_temp8, starting January 18, 2023. Also, because organizing the first meeting of the project will require significant time and effort, there is a need to have the NRSP Leadership Team identified and ready to go when the new project begins (i.e. October 1, 2023). Thus, a request for nominations for the elected leadership members (the chair, the chair-elect, three coordinators, three coordinator-elects) will be sent out by the co-chairs of the writing team (i.e. Stephanie McKay, University of Vermont, and Fiona McCarthy, University of Arizona) in August 2023. Once nominated individuals verify that they will participating in the new project, those NRSP members who are listed in NIMSS as participants in the new project will be asked to vote in September 2023 in an online election organized by the writing team co-chairs. This timeline will ensure that the elected members of the Leadership Team will have more than three months to plan the project's inaugural meeting, which will be held in January, 2024, in conjunction with the 2024 Plant and Animal Genome meeting in San Diego. During the first meeting, members will receive information on nominating Stakeholder Representatives and members of the External Advisory Board, and these individuals will be on board by March, 2024.

Planned Collaborations & Outreach: A key aspect of this proposal are the collaborations that will be facilitated in several ways with animal genomicists and:

- researchers in other subspecialties of animal sciences and their allied fields (e.g., nutrition, reproductive biology, veterinary medicine) though workshops and meetings at existing conferences (e.g., American Society of Animal Science and associated regional conferences);
- those in related informatics and engineering fields in order to develop capacity in new informatic techniques that can be applied to animal agriculture;
- groups working on open data sources that support better data management and standards within animal sciences (e.g. the FAIR Initiative);
- genomics/bioinformatics resources such as CyVerse and Galaxy to ensure support for sustainable training resources;
- collaborative links with existing projects such as the USDA-funded AG2PI, the AgBioData Consortium, and NRSP-10 National Database Resources for Crop Genomics, Genetics and Breeding Research;
- related multi-state projects that have genetic improvement/data sensing themes, including:
    - NC1170 Advanced Technologies for the Genetic Improvement of Poultry
    - NECC1901 Integrating Genomics and Breeding for Improved Aquaculture Production of Molluscan Shellfish
    - WERA1 Coordinating Beef Cattle Breeding Research and Education Programs for the Western States
    - S1086 Enhancing sustainability of beef cattle production in Southern and Central US through genetic improvement
    - S1069 Research and Extension for Unmanned Aircraft Systems (UAS) Applications in U.S. Agriculture and Natural Resources
    - NC1211 Precision Management of Animals for Improved Care, Health, and Welfare of Livestock and Poultry

The integration of activities with these projects is described in more detail in other sections of the proposal.

Outreach effort will focus on:

Expanding genomics capacity for all animal scientists. NRSP annual meetings will alternate between the International Plant and Animal Genome (PAG) and other meetings routinely attended by animal scientists (e.g., American Society of Animal Sciences, Beef Improvement Federation, National Cattlemen's Beef Association and National Swine Improvement Federation meetings). Outreach to other sectors of the broader community will occur through presentations, informational sessions and training opportunities at meetings attended by animal sciences researchers and other stakeholders (e.g., the Havemeyer meeting, Beef Improvement Federation Symposium, American Sheep Industry Convention). The outreach events will include presentations on how NRSP tools and resources have been applied in various research projects and in various species/industries, discussions about specific community needs and gaps, and hands-on training for our stakeholder groups (including our industry and breed association stakeholders). These outreach efforts will inform the broader community about research capacity that is either available or being developed and will include feedback so that new developments are aligned with stakeholder needs.

Developing informatics capacity for animal industries. Bioinformatics personnel routinely attend and present at informatics and association meetings (e.g., Data Carpentries, GMOD, Galaxy, CyVerse and the International Society of Biocuration). Therefore, we will use these meetings as conduits for developing cross-collaboration information exchanges with the broader informatics field. Capacity for animal scientists will be expanded through these exchanges and scientists working in informatics and agricultural engineering will learn of new opportunities for applying informatics techniques to animal industries. Partnering with these informatic associations will also provide novel opportunities to develop education and training in targeted areas as well as the recruitment of additional expertise and resources for the animal science areas.

Supporting education and training capacity. Outreach to both animal scientists and informaticians will be done through education and training programs. Our education efforts will focus on undergraduate and graduate students at land grant colleges and universities, including the 1862, 1890 and 1994 institutions. However, online educational resources will also be available to all participants of the NRSP project. Additionally, animal breeders, industry stakeholders, Extension personnel and the general public will be provided with non-technical information on genomics-enabled technologies and their application in agriculture. In this way, the successes of genomic-based research in farm animals will be disseminated and celebrated.

The project leadership will also engage with regulatory and funding agencies to ensure broad perspectives on the needs of genomics-enabled technologies across all animal industries. These conversations will also lead to funding for additional activities of this project and new research that may be developed because of capacity expansion that are outcomes of the project.

Outcome Delivery Schedule: The key milestones of this NRSP are described below. The project Chairs and Coordinators will be responsible for ensuring that all members and stakeholders are positioned to meet the targeted deliverables.

Year 1. *Aim 1:* Produce surveys for animal science researchers; community discussion regarding data deposition guidelines. *Aim 2:* Develop initial stakeholder and informatics and engineering groups for discussions via open expressions of interest. *Aim 3:* Develop test-cases for educational modules; collect information about internship opportunities; determine needs/interest for training programs.

Year 2. *Aim 1:* Distribute survey results; develop test-cases for data deposition; organize community workshops on data reuse. *Aim 2:* Hold industry-specific roundtables; develop links with informatics and engineering experts. *Aim 3:* Assess training modules; review and assess internship co-ordination; deliver training workshops.

Year 3. *Aim 1:* Publish survey results; assess development of data deposition guidelines; organize follow-up with stakeholders on data reuse workshops. *Aim 2:* Complete industry-specific round tables and report on industry needs. *Aim 3:* Expand educational modules; offer and evaluate internship experiences; expand training workshops; provide mid-project review and assessment of project activities.

Year 4. *Aim 1:* Distribute data deposition resources to the community. *Aim 2:* Host interdisciplinary discussions to foster collaborations. *Aim 3:* Add educational modules; offer and evaluate internship experiences; provide training workshops.

Year 5. *Aim 1:* Publish report on data reuse. *Aim 2:* Deliver outreach at bioinformatics, biocuration and related informatics meetings. *Aim 3:* Assess education modules and revise as needed; review

and assess internship coordination; assess training workshops and revise as needed; provide final report and assessment of project activities.

Additional sources of funding: In addition to the OTT Multi-state Research Funding (MRF) provided by SAES, members of the NRSP project will be proactive in seeking and obtaining funding from additional sources to expand resources and address issues relevant to the project. For example, NRSP-8 members have submitted a conference proposal to AFRI supporting early career scientists who want to use genomics in their research projects to attend the Advances in Genome Biology and Technology – Agriculture (AGBT-Ag) meeting in 2023. Another example of additional funding are internship opportunities that are offered by several of our industry partners. We intend to redirect these internships to this project by training students in genomics techniques and then placing the students with relevant industry partners. Additional research experiences for students will be expanded with new stakeholders offering internships. Other sources of funding that will be sought for this project include grants and industry sponsorship for meetings, and competitive funding from agencies such as AFRI, NSF and FFAR to support workforce training focused on genomics capacity.

Sustainability: This NRSP proposal includes provisions for sustaining capacity beyond the initial OTT MRF funding. Specific activities are designed to enhance competitive funding for those scientists trained through and included in this project. Also, initial assessments of stakeholder needs will form the basis of a white paper that focuses attention on the needs of the scientific community and then project members will be encouraged to develop collaborative grants, with project activities designed to enhance the grant proposals.

It should be noted that new funding that spans research, education and training workshops will be one of the measures of project impacts. Furthermore, partnering on bioinformatics resources and educational initiatives will allow us to effectively leverage existing capacity that will be directed towards helping the animal industries.

Industry stakeholders have indicated the need for employees who have expertise in data management and analysis. We will partner with stakeholders to support and develop internships and similar experiential training opportunities so that those workforce needs are met.

A key component for sustaining capacity is to ensure that genomic resources are widely dispersed and easily accessible by multiple groups and users with different levels of expertise. With support from the EAB and industry stakeholders, we will develop policies for ensuring that the resources developed within this project are disseminated. For example, we foresee the distribution of analysis workflows/software to different bioinformatic platforms (e.g., CyVerse, Galaxy, GitHub, BioContainers).

2. Budget and Budget Narrative

While the budget presented below outlines a detailed distribution of funds, revisions of the budget may be needed in order to better align resources across the project's aims and activities over the lifetime of the project. Budget revisions will be collaboratively developed by the project's Administrative Advisors, the NRSP Leadership Team, and the EAB and then approved by the Administrative Advisors.

OTT Multistate Research Funding requested within this proposal:

A. Salary ($184,845)

Program Coordinator ($85,245): This quarter-time position ($17,049/year for years 1-5) will handle details of meetings and workshops, coordinate travel, and collate student-mentor surveys related to this project. The Program Coordinator will also manage all administrative details for undergraduate and graduate students involved in the project, and ensure that the students have access to computer resources.

Graduate student stipends ($99,600): Summer support will be provided to a total of 12 graduate students ($8,300 per student), with three students each year in years 1-4. Graduate students will work with mentors to develop bioinformatic workflows. Students will be selected by an independent review panel after a nationwide call to advertise the positions.

B. Fringe benefits ($40,155):

Fringe benefit rate for the program coordinator (calculated at 31.9%) and graduate students (calculated at 13%).

C. Equipment ($0): None requested.

D. Travel ($175,910):

1. Domestic ($175,910): Travel funds are based on estimated travel expenses.

(i) Annual Meetings: Five NRSP Leadership Team members (Chair, three Coordinators, one non-industry Stakeholder Representative) to attend annual project meetings in years 1-5. Estimated as $1,000 flight, two nights' accommodation ($150/night) and per diem for three days ($90/day) for a total of $1,570 per person per meeting.

(ii) Data Management Workshops: Two trainers to deliver 2-day workshops at stakeholder meetings in years 1-5 on aspects of data management. Estimated as $1,000 flight, three nights' accommodation ($150/night) and per diem for four days ($90/day) for a total of $1,810 per trainer per meeting.

(iii) Roundtable Discussions: Up to ten stakeholders, researchers, engineers and informaticians to meet annually in years 1-5. Estimated as $1,000 flight, two nights' accommodation ($150/night) and per diem for three days ($90/day) for a total of $1,570 per person per meeting.

(iv) Bioinformatics Training Workshops: Two trainers to deliver 2-day workshops at stakeholder meetings in years 1-5 on bioinformatics. Estimated as $1,000 flight, three nights' accommodation ($150/night) and per diem for four days ($90/day) for a total of $1,810 per trainer per meeting.

(v) Students and Early-career Researchers: Up to three students or early career researchers to attend annual meeting in years 3-5. Estimated as $1,000 flight, 6 nights' accommodation ($150/night) and per diem for six days ($90/day) for a total of $2,440 per attendee per meeting.

2. Foreign ($0): None requested.

E. Other Direct Costs ($101,350)

1. Materials and Supplies ($1,000): Costs of workshop and training materials are estimated at $200 per year for years 1-5.

2. Publication Costs ($4,000): Costs related to publications arising from this project are requested at $4,000 in year 5. Typically, bioinformatics and genomics manuscripts are published in online, open-source journals that require an article-processing charge.

3. Consultant ($0): None requested.

4. ADP/Computer Services ($0): None requested.

5. Subawards/Consortium/Contractual Costs ($46,000): A sub-contract to Iowa State University will be used to support one-month salary and fringe benefits for the database/website manager ($7,700/year) and for servers/storage ($1,500/year) for years 1-5.

6. Equipment or Facility Rental/User Fees ($20,000): Funding for space and IT for the data management and bioinformatics training workshops is requested at $4,000 per year for years 1-5.

7. Alterations and Renovations ($0): None requested.

8. Other 1 ($14,550): Conference registration for students and early-career researchers to attend meetings in years 3-5 and for workshop trainers in years 1-5 is requested (based upon ASAS registration of $675 for members and $175 students).

Total Requested: $502,254

Additional sources of funding:

Project participants will be encouraged to seek additional funding to support the activities, data, resources and educational materials developed herein. This directive has a high probability of success; in fact, NRSP-8 participants have been highly successful leveraging research funding using the NRSP-8 tools and resources, with an average return on investment of more than $20 for each dollar provided to the NRSP-8 project. Grants for conferences and meetings as well as education and training grants will be developed, and the funding will allow expansion of the project's outreach activities. Moreover, strong linkages with our industry stakeholders, included in project management and decision making, will create opportunities for seeking industry sponsorship of meetings and training activities.

It should be noted that matching funds are not yet in hand. However, the values presented below and in the budget table are anticipated minimum thresholds. In fact, significant matching funds were generated by members of the NRSP-8 members over the life of the NRSP-8 project and including funding from industry partners, conference and research grants, conference and workshop sponsorships, education foundations, etc.

A. Salary ($24,900):

Matching graduate student stipends ($24,900): Summer support ($8,300 per student) for a graduate student each year for years 1-3. Students will develop analysis workflows and bioinformatic workflows. Applicants for the project will be sought through a nationwide announcement of the position and then selected by an independent panel.

B. Fringe benefits ($3,237):

Fringe benefit rate for graduate students (13% of salary).

C. Equipment ($0): None.

D. Travel ($54,950):

1. Domestic ($54,950):

Travel of External Advisory Board members. It is anticipated that the industry members of the External Advisory Board (up to seven) will support their own travel to the annual meeting in years 1-5. Estimated as $1,000 flight, two nights' accommodations ($150/night) and per diem for three days ($90/day) for a total of $1,570 per person per meeting.

2. Foreign ($0): None requested.

E. Other Direct Costs ($16,000)

1. **Materials and Supplies ($0):** None.
2. **Publication Costs ($0):** None.
3. **Consultant ($0):** None.
4. **ADP/Computer Services ($0):** None.
5. **Subawards/Consortium/Contractual Costs ($0):** None.
6. **Equipment or Facility Rental/User Fees ($16,000):** Matching funds ($2,000/workshop p.a.) will be sought from industry sponsors of the data management and bioinformatics training workshops and used to offset conference expenses in years 2-5 are estimated.
7. **Alterations and Renovations ($0):** None.
8. **Other ($0):** None.

Total: $99,087

C. Integration and Documentation of Research Support:

1. Integration with Extension, academic, or international programs

The proposed organizational structure is designed to ensure integration of capacity with Extension, academic and international programs. Current NRSP-8 membership is predominantly comprised of academicians with extension, teaching, and research appointments, thus promoting communication through extension and outreach with stakeholders and industry representatives. We will build upon NRSP-8 sponsored conversations with industry representatives, which requires sustained conversations to develop knowledge, trust and understanding. Finally, it should be noted that the current membership of NRSP-8 includes 105 members from 49 institutions at 36 US states and six additional countries. A historic example of NRSP-8 supported international collaboration are efforts supporting the sequencing of key livestock genomes (10–14). More recent examples of NRSP-8 supported international collaborations include FAANG and AG2PI, both of which are high priority multi-species international projects that include and benefit NRSP-8 members. International partners will also be connected at scientific meetings (e.g., ASAS, ADSA, PAG, ISAG, SSR, WCGALP).

2. Engagement in project planning and implementation

The previous NRSP-8 program resulted in numerous new partnerships within the last five years. During this time, we held three stakeholder panels with representatives from all major USDA animal genome species. Industry participants represented both US and global animal industries, as well as animal genetics companies and breed associations. The feedback provided by these participants has been essential for developing the aims of the current proposal. During the same period, we created partnerships within the international FAANG and note that this project was initially proposed and developed as a direct consequence of the NRSP-8 project. Other partnerships that have developed from NRSP-8 activities include the AFRI funded projects developing pangenome resources for chicken, sheep, and cattle; several competitively funded telomere-to-telomere sequencing projects; the Agricultural Genome to Phenome Initiative (AG2PI); and strengthened linkages between NRSP-8 members and the AgBioData and NRSP-10 projects.

While NRSP-8 has been highly successful, ***this proposal is substantially different from the NRSP-8 project*.** Funding for the NRSP-8 Species and Bioinformatics Coordinators is not requested in this project, and genomics tools and resources will not be the primary focus. Instead, the overall objective is the development of new genomics capacity across a multitude of areas. The project's implementation leverages lessons learned within NRSP-8. For example, we anticipate a smooth transition from NRSP-8 to the new leadership team by seeking nominations of chairs and coordinators from NRSP-8 members. However, all elected members of the new Leadership Team must be active members of the new project. Stakeholders are engaged via the EAB and through individual activities that span the duration of the project. Members will be asked to identify their interest in specific aims and activities, and all members will be updated on all aims and activities at the annual meeting and via the annual written report. Moreover, all members are involved in selecting the NRSP's leadership team via the nomination and election processes.

3. Integration with multistate projects

This project will provide critical data and training resources to allow a wide range of scientists and researchers to use genomics and phenomics tools in their sub-disciplines of animal science. New workflows and case studies will be designed for connecting genomics with emerging technologies that are coming forward in animal agriculture. For example, the sensing and high-throughput phenotyping that validates behavioral responses in farm animals could be analyzed to identify the underlying genetics that control behavior. The project will also provide training through workshops associated with scientific meetings, websites and other virtual materials to the broader animal sciences community. Training will include sessions on a variety of topics such as how to use new analysis software, best practices when conducting genomic analyses, identifying phenomic patterns and anomalies, and reusing (and archiving) previously collected data. It is anticipated that training may also be needed for new statistical approaches such as machine learning and AI. Obviously, these training modules will be useful to a wide range of discipline- specific multistate projects related to animal science and will also be pertinent in agricultural engineering and other related fields. Our plans for integration with other multi-state projects are outlined in the Business Plan.

D. Outreach, Communications, and Assessment:

1. Communication Plan

Target Audience. The primary beneficiaries of this NRSP include:

- Research scientists directly engaged in animal genetics, genome research, and animal breeding.
- Scientists utilizing publicly accessible genomic data in their respective animal science fields as well as complementary research in veterinary medicine, human physiology and medicine, informatics, engineering, biology, ecology, and rangeland science.
- Faculty, researchers, and graduate and postdoctoral students who want to apply new techniques in animal genomics to their research projects.
- Stakeholders, as defined and described in previous sections.

Support of research, education, and communication activities in animal genomics also benefits public consumers of US animal agriculture products. Outcomes include improvements in the quality, safety and wholesomeness of animal products, economic efficiencies, and environmental stewardship of animal production systems.

Communication Plan. The primary mechanism for distribution of NRSP results and accomplishments will be via annual reports publicly available on NIMSS (https://www.nimss.org/). However, we will also disseminate information about our activities and outcomes via peer-reviewed publications, white papers, and conference presentations. These products will be listed in the annual report posted on NIMSS and through other public channels, such as journal websites and relevant press releases. To engage with stakeholders and promote the project, these communications will also be featured on the project website, which will also contain training and educational resources developed within the project. The website will also be integrated into a list-serv that allows direct connection with members and stakeholders for disseminating information about upcoming project activities and opportunities.

2. Stakeholder engagement

Our stakeholders are defined and described in the previous section, and details on how they will be integrated into this project are outlined in the Business Plan section. Briefly, stakeholders will be engaged at multiple points and will have an important role in shaping the outcomes of this project. Examples of stakeholder engagement are:

- A stakeholder advisory group (the Executive Advisory Board) will be created and meet annually with the project Leadership Team. The EAB will provide critical feedback on how project activities meet stakeholder needs.
- Stakeholders will be included on the project list-serve, which will be used to promote communication and dissemination of project activities and outcomes.
- Stakeholders will be encouraged to attend the annual project meetings.
- Workshops and training modules will be designed and focused on stakeholder needs.
- Surveys and discussions with stakeholders representing diverse industries and priorities are incorporated throughout the three Specific Aims.
- Experiential internships will link stakeholders with students, creating pipelines for data-savvy future employees as well as identify gaps in student knowledge.

3. Measuring accomplishments and outcomes

The accomplishments of capacity-building projects are measured in terms of resources development, interdisciplinary collaborations, and knowledge transfer. The project Leadership Team will document accomplishments in annual progress reports, including:

- Published protocols and case studies that support bioinformatics analysis of animal genomics data sets and their integration into existing bioinformatics workflows.
- Development and use of guidelines to support best practice in bioinformatic analysis of genomics data sets and the reuse of data.
- Reports, white papers and publications describing outcomes from workshops, roundtables, and training events.
- Attendance of stakeholders at NRSP activities, including training workshops.
- Development of training, education and Extension materials and opportunities.
- Students participating in experiential education and internship opportunities.
- Publications and grant submissions that are outcomes of new collaborative opportunities established through this project.

Methods to measure program accomplishments have been described in previous sections of this proposal and include:

- An annual request from the Specific Aim Coordinators to all program participants to provide information on accomplishments and publications linked to the project.
- Routine searches of scholarly repositories, journal articles and professional reports.
- Compilations of project website use statistics.
- Participation in NRSP activities.

The impact of these accomplishments lies in their successful application to animal industries. This will be assessed by measuring usage of resources (e.g., online access and downloads), number of people who complete training and education activities, citations and downloads of publications and reports, stakeholder participation in the activities, and the ability of members to leverage project resources, activities and collaborations into research, education, extension and conference grants across federal and state agencies, as well as to research and philanthropic foundations.

4. Development of communication pieces

The Leadership Team will organize annual reports which include accomplishments, outcomes and impacts. The report will be shared with NRSP members and stakeholders via the NIMSS reporting system and the project website and list serve. The Leadership Team and the External Advisory Board will identify a subset of project impacts and accomplishments that will have broader distribution across the Multistate Research Fund Impacts Program, State Agricultural Experiment Stations and leadership of the land-grant universities. As outlined above, project accomplishments and outcomes will also be disseminated at scientific conferences and professional association meetings.

5. Data management plan

The goal of this capacity proposal is not to directly fund the acquisition of new data tools and resources but rather to support scientists who are using or wish to use them. NRSP

members will be trained in best practices for data management, including analysis, sharing, and re-use of data. Members are expected to support responsible data management and routinely meet or exceed federal and community data management policy and best practices. This includes agreement to abide by the Toronto principles for data release, the Fort Lauderdale policy for rapid pre-publication release of data sets, and federal data sharing policies and requirements, including the USDA Guidelines for Data Management Planning. Goals of this project include the support of members in meeting these standards and to develop best practices for sharing data within the constraints of established commercial confidentiality.

Resources developed as a direct result of this project will be managed, archived, and made available to prospective users via publication in scientific journals, dissemination at meetings and conferences, through the project website and indirectly through links to other well-established platforms for resource sharing (e.g., GitHub, biocontainers, bioinformatic platforms and protocols.io). All products from this proposal will be available or linked to via a project website we will set up for this purpose.

6. Suggested mechanisms for distribution of the results of the research support project

Many of the NRSP-8 coordinators and members have held advisory roles with USDA or other US agencies, offices, departments, or committees including:

- USDA ARS
- USDA APHIS
- USDA NIFA Southern Regional Aquaculture Center
- US DHS Analytic Exchange Program
- US DHS Cybersecurity and Infrastructure Security Agency
- US DHS Countering Weapons of Mass Destruction
- National Oceanic and Atmospheric Administration
- White House Rural Council.

As such, the NRSP-8 community expertise is well respected and communication channels to a diverse set of stakeholders are already in place. Furthermore, industry contacts serve in advisory roles for NRSP-8 and they provide and receive input that guides the research community. The NRSP-8 membership represents 49 institutions across 36 US states and six additional countries. Our established mailing list includes additional parties interested in this work, representing more than 3,000 individuals from 50 countries. These connections and networks will be used to distribute project results from the new project both nationally and internationally.

As described in previous sections, our goal is to have the project resources and reports widely disseminated, and this will ensure that the capacity developed by this project is sustainable after the funding is completed. While resources and accomplishments will be available on the project website, we expect that they will primarily be distributed to the community via well-established sharing platforms such as existing bioinformatics platforms (e.g., Galaxy, GitHub, Biocontainers, Data Carpentries and Protocols.io). These resources already have active communities and expertise for us to leverage and familiarity with these resources will also help our community to develop additional expertise and collaborations. Resources developed as part of this NRSP will acknowledge NIFA Hatch funding, and members will be provided with reminder and suggested language for this. Resources and accomplishments will also be shared at the annual meetings, which will be associated with regular conferences and meetings to support outreach to our stakeholders.

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2. Budget and Budget Narrative (NRSP Budget Requests Summary Form).

OTT Multistate Research Funding requested:

Description	Budget 2023-24	Budget 2024-25	Budget 2025-26	Budget 2026-27	Budget 2027-28
Salaries/Wages	41,949	41,949	41,949	41,949	17,049
Fringes	8,676	8,676	8,676	8,676	5,439
Total FTE	0.75	0.75	0.75	0.75	0.25
Travel	30,790	30,790	38,110	38,110	38,110
Equipment/Capital Improvement	0	0	0	0	0
Other (materials, publications)	17,550	17,550	20,750	20,750	24,750
TOTAL	**$98,965**	**$98,965**	**$109,488**	**$109,488**	**$85,348**

A. Salary ($184,845)

Program Coordinator ($85,245): This quarter-time position ($17,049/year for years 1-5) will handle details of meetings and workshops, coordinate travel, and collate student-mentor surveys related to this project. The Program Coordinator will also manage all administrative details for undergraduate and graduate students involved in the project, and ensure that the students have access to computer resources.

Graduate student stipends ($99,600): Summer support will be provided to a total of 12 graduate students ($8,300 per student), with three students each year in years 1-4. Graduate students will work with mentors to develop bioinformatic workflows. Students will be selected by an independent review panel after a nationwide call to advertise the positions.

B. Fringe benefits ($40,155):

Fringe benefit rate for the program coordinator (calculated at 31.9%) and graduate students (calculated at 13%).

C. Equipment ($0): None requested.

D. Travel ($175,910):

1. **Domestic ($175,910):** Travel funds are based on estimated travel expenses.
   (i) Annual Meetings: Five NRSP Leadership Team members (Chair, three Coordinators, one non-industry Stakeholder Representative) to attend annual project meetings in

years 1-5. Estimated as $1,000 flight, two nights' accommodation ($150/night) and per diem for three days ($90/day) for a total of $1,570 per person per meeting.

(ii) Data Management Workshops: Two trainers to deliver 2-day workshops at stakeholder meetings in years 1-5 on aspects of data management. Estimated as $1,000 flight, three nights' accommodation ($150/night) and per diem for four days ($90/day) for a total of $1,810 per trainer per meeting.

(iii) Roundtable Discussions: Up to ten stakeholders, researchers, engineers and informaticians to meet annually in years 1-5. Estimated as $1,000 flight, two nights' accommodation ($150/night) and per diem for three days ($90/day) for a total of $1,570 per person per meeting.

(iv) Bioinformatics Training Workshops: Two trainers to deliver 2-day workshops at stakeholder meetings in years 1-5 on bioinformatics. Estimated as $1,000 flight, three nights' accommodation ($150/night) and per diem for four days ($90/day) for a total of $1,810 per trainer per meeting.

(v) Students and Early-career Researchers: Up to three students or early career researchers to attend annual meeting in years 3-5. Estimated as $1,000 flight, 6 nights' accommodation ($150/night) and per diem for six days ($90/day) for a total of $2,440 per attendee per meeting.

2. Foreign ($0): None requested.

E. Other Direct Costs ($101,350)

1. Materials and Supplies ($1,000): Costs of workshop and training materials are estimated at $200 per year for years 1-5.

2. Publication Costs ($4,000): Costs related to publications arising from this project are requested at $4,000 in year 5. Typically, bioinformatics and genomics manuscripts are published in online, open-source journals that require an article-processing charge.

3. Consultant ($0): None requested.

4. ADP/Computer Services ($0): None requested.

5. Subawards/Consortium/Contractual Costs ($46,000): A sub-contract to Iowa State University will be used to support one-month salary and fringe benefits for the database/website manager ($7,700/year) and for servers/storage ($1,500/year) for years 1-5.

6. Equipment or Facility Rental/User Fees ($20,000): Cost of space and IT for the data management and bioinformatics training workshops are requested at $4,000 per year for years 1-5.

7. Alterations and Renovations ($0): None requested.

8. Other 1 ($14,550): Conference registration for students and early-career researchers to attend meetings in years 3-5 and for workshop trainers in years 1-5 are requested (based upon ASAS registration of $675 for members and $175 students).

Total: $502,254

Additional sources of funding:

Project participants will be encouraged to seek additional funding to support the activities, data, resources and educational materials developed herein. This directive has a high probability of success; in fact, NRSP-8 participants have been highly successful leveraging research funding using the NRSP-8 tools and resources, with an average return on investment of more than $20 for each dollar provided to the NRSP-8 project. Grants for conferences and meetings as well as education and training grants will be developed, and the funding will allow expansion of the project's outreach activities. Moreover, strong linkages with our industry stakeholders, included in project management and decision making, will create opportunities for seeking industry sponsorship of meetings and training activities.

It should be noted that matching funds are not yet in hand. However, the values in the budget table are anticipated to be minimum thresholds. In fact, significant matching funds were generated by members of the NRSP-8 members over the life of the NRSP-8 project and including funding from industry partners, conference and research grants, conference and workshop sponsorships, education foundations, etc.

Description	**Budget 2023-24**	**Budget 2024-25**	**Budget 2025-26**	**Budget 2026-27**	**Budget 2027-28**
Salaries/Wages	8,300	8,300	8,300	0	0
Fringes	1,079	1,079	1,079	0	0
Total FTE	0.25	0.25	0.25	0.00	0.00
Travel	10,990	10,990	10,990	10,990	10,990
Equipment/Capital Improvement	0	0	0	0	0
Other (materials, publications)	0	4,000	4,000	4,000	4,000
TOTAL	**$20,369**	**$24,369**	**$24,369**	**$14,990**	**$14,990**

A. Salary ($24,900):
Matching graduate student stipends ($24,900): Summer support ($8,300 per student) for a graduate student each year for years 1-3. Students will develop analysis workflows and bioinformatic workflows. Applicants for the project will be sought through a nationwide announcement of the position and then selected by an independent panel.

B. Fringe benefits ($3,237):
Fringe benefit rate for graduate students (13% of salary).

C. Equipment ($0): None.

D. Travel ($54,950):

1. Domestic ($54,950):

Travel of External Advisory Board members: It is anticipated that the industry members of the External Advisory Board (up to seven) will support their own travel to the annual meeting in years 1-5. Estimated as $1,000 flight, two nights' accommodations ($150/night) and per diem for three days ($90/day) for a total of $1,570 per person per meeting.

2. Foreign ($0): None requested.

E. Other Direct Costs ($16,000)

1. **Materials and Supplies ($0):** None.
2. **Publication Costs ($0):** None.
3. **Consultant ($0):** None.
4. **ADP/Computer Services ($0):** None.
5. **Subawards/Consortium/Contractual Costs ($0):** None.
6. **Equipment or Facility Rental/User Fees ($16,000):** Matching funds ($2,000/workshop/year) will be sought from industry sponsors of the data management and bioinformatics training workshops and used to offset conference expenses in years 2-5 are estimated.
7. **Alterations and Renovations ($0):** None.
8. **Other ($0):** None.

Total: $99,087

Table of Contents

October 12, 2022

Dear Agriculture Experiment Station Directors,

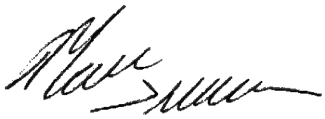
I am writing in support of the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries.

By way of introduction, I currently serve as the Vice President and General Manager of Innovasea's Land-Based Aquaculture Division. Innovasea is a global leader in technologically advanced aquatic solutions for aquaculture and fish tracking.

I understand that the overall objective of this proposal is to develop resources to support the application of genomics technologies to agriculture animal industries. I understand that the aims of this proposal include developing resources and support for genomic analyses; integrating this with other data types collected by producers in my industry; and linking with industry partners to help train a data savvy workforce for US agriculture—and aquaculture is agriculture.

I look forward to working with State Agricultural Experiment Station personnel via workshops and community discussions as they arise and that this NRSP intends to inform partners and members on new genomic developments and technologies.

Sincerely,



Marc J. Turano, PhD
Vice President and General Manager of Land-Based Aquaculture
Innovasea

THE CENTER FOR AQUACULTURE TECHNOLOGIES

Dear Station Directors,

I am writing in support of the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries.

By way of introduction, I am Debbie Plouffe and I work with the Center for Aquaculture Technologies. The mission of my company is to lead the aquaculture industry in the delivery of genomics technologies through a variety of innovative applications. We are particularly interested in ensuring that the products and outcomes of genomics research are applied in a pragmatic and cost-effective way to facilitate uptake across the broad array of stakeholders and markets characteristic of the global aquaculture industry. In addition, we are invested in developing effective communication tools and learning opportunities that will support the commercialization of genomics technology by engaging with consumers and other stakeholders in the farmed seafood supply chain.

I understand that the overall objective of this proposal is to develop resources to support the application of genomics technologies to animal industries. I understand that the aims of this proposal include developing resources and support for genomic analyses; integrating this with other data types collected by my industry; and linking with industry partners to help develop a data savvy workforce for US agriculture. These aims will support my company/my industry by ensuring that our organization is able to maintain a leadership position in the field of applied genomics in aquatic species including development of a skilled workforce and knowledgeable stakeholder base to support our company growth.

I look forward to working with State Agricultural Experiment Station personnel via our participation in workshops, surveys, community discussions and training opportunities.

We are excited about collaboratively working to improve or enhance the future of agriculture genomics.

Regards,

Debbie Plouffe, PhD
Vice President, Business Development
The Center for Aquaculture Technologies

www.aquatechcenter.com
info@aquatechcenter.com
The Center for Aquaculture Technologies
8445 Camino Santa Fe, Suite 104, San Diego, CA 92121 USA
20 Hope Street, P.O. Box 388, Souris, PEI C0A 2B0 Canada
797 Victoria Road, PO Box 388, Victoria, PEI C0A 2G0 Canada

Troutlodge

The logical choice

Troutlodge Inc.
P.O. Box 1290
Sumner, WA 98390
+1 253 863 0446
www.troutlodge.com

July 25, 2018

Dear Station Directors,

I am writing in support of the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries.

By way of introduction, I am Kyle Martin, senior geneticist for Hendrix Genetics, with direct responsibility for our Trout and shrimp breeding programs. The mission of my company is to support the global food challenge by providing high quality animal genetics to commercial farms. As part of that mission, we utilize the latest advances in technology to increase efficiency of animal production. The improvement, and expansion of genetic technologies in animal breeding will help our company, and the broader animal breeding industry to better meet the global food challenge.

I understand that the overall objective of this proposal is to develop resources to support the application of genomics technologies to animal industries. I understand that the aims of this proposal include developing resources and support for genomic analyses; integrating this with other data types collected by my industry; and linking with industry partners to help develop a data savvy workforce for US agriculture.

I look forward to working with State Agricultural Experiment Station personnel via workshops revolving around common goas.

We are excited about collaboratively working to improve or enhance the future of agriculture genomics.

Regards,

Kyle Martin
Senior Geneticist
Kyle.Martin@hendrix-genetics.com

HENDRIX GENETICS

RIVERENCE®
BROOD · FARMS · PROVISIONS

October 24, 2022

Dr. Benjamin J. Reading
North Carolina State University
Department of Applied Ecology
Raleigh, NC 27695-7617

RE: National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries

Dr. Reading:

On behalf of Riverence, a group of privately-owned aquaculture companies based in Washington and Idaho, I am writing to express our support for the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries that you are coordinating. We enthusiastically support the proposal and, with this letter, indicate the intent of Riverence Holdings LLC to engage with you and the project cooperators to fully leverage the project's value to US aquaculture, should the proposal be funded.

By way of introduction, my name is Jesse Trushenski. I am the Chief Science Officer for the Riverence group. In this role, I shape and lead our R&D initiatives, including our selective breeding programs. Before joining the private sector, I was a tenured Associate Professor at Southern Illinois University (SIU) and Fish Pathologist Supervisor for the Idaho Department of Fish and Game (IDFG). At SIU, I established my research team as one of the leading aquaculture research groups in the country, publishing more than 160 peer-reviewed articles, essays, and lay summaries of our work in fish nutrition and physiology. During my time with IDFG, I led the Eagle Fish Health Laboratory, responsible for surveillance and diagnostics throughout the state of Idaho, to become the first in the country to be recognized by the American Fisheries Society (AFS) Fish Health Section via its laboratory accreditation program. I am also a Past President and Fellow of the American Fisheries Society, the oldest and largest professional society representing fisheries scientists worldwide.

As you know, Riverence Provisions LLC and Riverence Farms LLC—our farms and processing operations—are collectively the largest producer of Rainbow Trout and Steelhead in the Americas. Riverence Brood LLC—our breeding operation—is a producer of premium Rainbow Trout genetics and the only domestic commercial supplier of Atlantic Salmon and Coho Salmon eggs. As both breeders and farmers of trout and salmon, we recognize the significant challenges that face aquaculture, including the need for innovation in the breeding space.

Our vision is to retain wild-type vigor while shaping the attributes of trout and salmon to meet the demands of modern aquaculture. Selective breeding is a powerful tool, but traditional approaches have been limited by the ability of humans to accurately predict and pursue the right characteristics while being mindful of unintended consequences. Using the best available science, we strive to continuously improve the performance of our broods and bring new technologies within reach. Our ongoing research to identify more robust selection tools and translate advances in terrestrial crop and livestock production to aquaculture are particularly suited to the goals outlined in your proposal.

RIVERENCE®
BROOD · FARMS · PROVISIONS

I understand that the overall objective of your proposal is to develop resources to support the application of genomics technologies to agriculturally relevant animal species. The aims of this proposal—including developing resources and support for genomic analyses; integrating this with other data types collected by producers in my industry; and linking with industry partners to help train a data-savvy workforce for US agriculture—are well-aligned with Riverence's goals and industry-wide needs in aquaculture breeding. Aquaculture is agriculture, and it is a strength of this proposal that it draws upon the technologies, knowledge, and expertise of multiple agricultural sectors.

In closing, we applaud you and the project cooperators for proposing work that has a high potential to improve US seafood sustainability and security, as well as advancement of domestic aquaculture. We strongly support your NRSP proposal and encourage full funding for this project. Thank you for the opportunity to comment, and we look forward to engaging with you and State Agricultural Experiment Station personnel to conduct meaningful, actionable science and technology transfer in the aquaculture breeding space.

Best,

Jesse Trushenski, PhD
Chief Science Officer

AMERICAN, LAND-BASED AQUACULTURE

FOR THE FUTURE OF WILD SALMON

Profit From Genetic Progress

July 25, 2022

Dear Station Directors,

I am writing in support of the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries.

By way of introduction, I am Matthew McClure and I am the Lead Dairy Geneticist at ABS-Global, where the company's mission is "Pioneering animal genetic improvement to help nourish the world". We use genetic data to continuously develop better cows for farmers by selecting animals with desirable characteristics that help them to produce higher quality meat and milk in a sustainable manner. We are particularly interested in more effective applications of genetics and genomics data to improve our understanding of bovine performance.

I understand that the overall objective of this proposal is to develop resources to support the application of genomics technologies to animal industries. I understand that the aims of this proposal include developing resources and support for genomic analyses; integrating this with other data types collected by my industry; and linking with industry partners to help develop a data savvy workforce for US agriculture. These aims will support my company by helping to develop the critical talent needed in livestock genomics and breeding required to continue advancing animal agriculture.

I look forward to working with State Agricultural Experiment Station personnel via collaborations, community discussions, internship opportunities for students, and scientific discussions.

We are excited about collaboratively working to improve or enhance the future of agriculture genomics.

Sincerely,

Matthew McClure, PhD
Lead Geneticist, Dairy
ABS-Global
1525 River Road
Deforest, WI

July 19th, 2022

Dear Station Directors,

I am writing in support of the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries.

By way of introduction, I am Casey Droscha and I direct Research & Development at CentralStar Cooperative in Lansing, Michigan. The mission of my company is to enhance producer profitability through integrated services. Within the R&D laboratory, we utilize large volumes customer dairy records, diagnostic results and DNA extracts from milk, blood, and feces to develop phenome/genome comparisons to gain novel insights of the impact disease incurs on production and thus profitability in the context of genomic selection.

We are particularly interested in disease resilience, susceptibility and the genetic mechanisms that confer a given phenotype. We employ broad range of sequencing technologies to investigate host-pathogen interactions, epigenetic mechanisms, and immunogenetic relationships. We continually seek more effective applications for analysis of genomic data, utilizing education and training opportunities when possible, to generate valued-added information for our producers and the greater dairy industry.

I understand that the overall objective of this proposal is to develop resources to support the application of genomics technologies to animal industries. I understand that the aims of this proposal include developing resources and support for genomic analyses; integrating this with other data types collected by my industry; and linking with industry partners to help develop a data savvy workforce for US agriculture. These aims will support my company and industry by integrating resources and ideas into actionable domains for maximum utility for industry stakeholders while bolstering the next generation of agricultural data scientists.

I look forward to working with State Agricultural Experiment Station personnel via virtual training events, workshops, and offering internships in my laboratory.

We are excited about collaboratively working to improve or enhance the future of agriculture genomics.

Regards,

Casey Droscha

Casey Droscha Ph.D
Associate Director of Research & Development
CentralStar Cooperative

JOÃO DÜRR
Chief Executive Officer

COUNCIL ON DAIRY CATTLE BREEDING
4201 Northview Drive, Suite 302
Bowie, MD 20716
Phone: (240) 334 4164 Ext: 311
Email: joao.durr@uscdcb.com

July 20, 2022

Dear Agricultural Experimental Station Directors,

I am writing in support of the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries.

By way of introduction, I am João Dürr and I am the CEO of the Council on Dairy Cattle Breeding (CDCB). The mission of my company is "*To drive global dairy cattle improvement by using a collaborative database to deliver state-of-the-art genetic merit and performance assessments for the herd decision making*". We use genetic data to provide accurate and transparent genetic and genomic evaluations for a multitude of traits and dairy cattle breeds, offering dairy farmers the information they need to make sound breeding decisions. We are particularly interested in informing rural communities and youths about the opportunities around genomic technologies.

I understand that the overall objective of this proposal is to develop resources to support the application of genomics technologies to animal industries. I understand that the aims of this proposal include developing resources and support for genomic analyses; integrating this with other data types collected by my industry; and linking with industry partners to help develop a data savvy workforce for US agriculture. These aims will support the dairy industry by preparing producers and service providers to make optimal use of the genomic tools that CDCB provides.

I look forward to working with State Agricultural Experiment Station personnel via workshops and training events.

We are excited about collaboratively working to improve or enhance the future of agriculture genomics.

Sincerely,

João Dürr
Chief Executive Officer

peakgenetics.com

July 27, 2022

Dear Station Directors,

I am writing in support of the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries. This proposal is very important because it addresses long-term infrastructure needs that benefit the entire community. Public investment in this area makes a lot of sense because the alternative is that individual organizations reinvent the wheel over and over again, with varying degrees of quality and success, and the rate of scientific progress is slowed because of disparities in access to resources and barriers to communication which result from the use of different vocabularies.

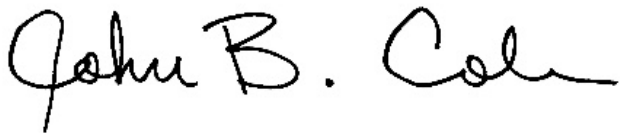
URUS Group LP is the largest supplier of bovine genetics in the world through our Alta, GENEX, and Jetstream brands, and international partnerships with CRV, Masterrind, and other leading companies. My research and development team is responsible for the ongoing development of our proprietary bull fertility evaluations, as well as other genetics tools that provide value to our customers. Almost all livestock genetics companies routinely make use of genomic information (single nucleotide polymorphisms and whole-genome DNA sequence data) to improve the accuracy of genetic predictions and develop insight into important biological processes. The broad portfolio of resources provided by NRSP-8 (AnimalQTLdb, trait ontologies, FAANG, etc.) has been very valuable for our past research efforts and will continue to be important. The success of this project underscores the value of community-based projects that avoid needless duplication and provide a common vocabulary for communications.

I understand that the overall objective of this proposal is to develop resources to support the application of genomics technologies to animal industries. This includes developing resources and support for genomic analyses; integrating this with other data types collected by our industry; and linking with industry partners to help develop a data savvy workforce for US agriculture. These aims will support our mission by ensuring the availability of high-quality, curated community resources; sharing resources to make the most of the funding and personnel available for research using large-animal models; and training the next generation of scientists and technicians in the data skills that are essential in all areas of the genetics industry today.

We at PEAK Genetics will continue to work with State Agricultural Experiment Station personnel in a variety of ways, including participation in workshops and training events, providing internship opportunities, and sharing feedback through surveys, community discussions, and one-on-one interactions.

We are excited about collaboratively working to improve or enhance the future of agriculture genomics.

Regards,



John B. Cole, Ph.D.
PEAK Senior VP, Research & Development
URUS Group LP
2418 Crossroads Dr., Suite 3600
Madison, WI 53718
john.cole@peakgenetics.com

Adjunct Professor
Department of Animal Science
North Carolina State University

Sustaining Courtesy Faculty
Department of Animal Sciences
University of Florida

2022/07/25

Dear Station Directors,

I am writing in support of the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries.

By way of introduction, I am Mehdi Sargolzaei, Director of Genetic Research and Technology, and I work with Select Sires Inc. company. The mission of my company is to enhance the productivity and profitability of dairy and beef producers, Select Sires Inc. is committed to be the premier provider of highly fertile, superior genetics accompanied by effective reproductive- and herd-management products and services. We use/intend to use genetic data to develop elite genetics for higher production while making genetic progress on resiliency to climate change, reducing carbon footprint of the animals and preserving genetic diversity in cattle populations. We are particularly interested in activities to develop more effective applications of genetics and genomics data. As well as education and training efforts for students and producers to make full use of this information.

I understand that the overall objective of this proposal is to develop resources to support the application of genomics technologies to animal industries. I understand that the aims of this proposal include developing resources and support for genomic analyses; integrating this with other data types collected by my industry; and linking with industry partners to help develop a data savvy workforce for US agriculture. These aims will support my company/my industry by better understanding the genetic architecture of current traits using larger data set and better genomic tools and by helping to develop potential novel traits which can bring more profitability to US producers.

I look forward to working with State Agricultural Experiment Station personnel via workshops, internships or other training events that effectively transfers this developing technology to those that can best make use of it.

We are excited about collaboratively working to improve or enhance the future of agriculture genomics.

Sincerely,

Mehdi Sargolzaei
Director of Genetic Research and Technology
Select Sires Inc.
msargolzaei@selectsires.com

ARABIAN
HORSE ASSOCIATION

July 15, 2022

Dear Dr. Bellone and Station Directors,

I am writing in support of the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries including the horse.

As the registrar of the Arabian Horse Association (AHA), I have the responsibility of working closely with our 15,500 members and registering 3,400 horses annually with our association. We utilize genetic testing for parentage verification and many of our members use genetic testing for mate selection to avoid producing foals with one of the four known recessive health traits in our breed. One of these traits was the first genetic defect discovered in horses in 1997, namely, severe combined immunodeficiency syndrome. There is no doubt that genetic testing has enabled the production of healthier horses for our breed over the last two and a half decades. Our association is committed to advancing the understanding and application of genetics as it relates to the Arabian Horse, and we are excited to partner with the researchers around the globe to further advance our knowledge of the Arabian horse.

I understand that the overall objective of this proposal is to develop resources to support the application of genomics technologies to animal industries. I am pleased to see that the aims of this proposal include developing resources and support for genomic analyses; integrating this with other data types collected by the equine industry; and particularly your goal of linking with industry partners to help develop a data savvy workforce for US agriculture. These aims will more greatly support the objectives of the AHA.

I look forward to working with State Agricultural Experiment Station personnel via continued engagement with genetics researchers and through community discussions, surveys and survey feedback.

We are enthusiastic about collaboratively working to improve or enhance the future of agriculture genomics.

Regards,

Deborah K. Fuentes

Deborah Fuentes
Registrar and Senior Director of Registry Services
Arabian Horse Association

303.696.4500 | 303.696.4599 fax | 10805 East Bethany Drive | Aurora, CO 80014 | ArabianHorses.org

July 11, 2022

AMERICAN QUARTER HORSE ASSOCIATION

Veterinary Genetics Laboratory
University of California
PO Box 1102
Davis, CA 95617

Dear Dr. Bellone and Station Directors:

I am writing in support of the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries including the horse.

As the registrar of the American Quarter Horse Association (AQHA), I have the responsibility of working closely with our members and registering horses with our association. We have been using genetic testing since the beginning of DNA testing for parentage exclusion in the early 1990s. Our organization registers 75,000 horses annually. We require that all stallions registered with the AQHA be tested for five known genetic diseases before any of their foals can be registered, with a sixth disease being added in 2023. Our members actively utilize genetic testing for both coat color and disease traits for marker assisted selection. Our organization is currently in the process of developing many educational materials to assist our members to better utilize the genetic testing that is available. All that to say our association is committed to advancing the understanding and application of genetics as it relates to the American Quarter Horse and as outlined in your proposal.

I understand that the overall objective of this proposal is to develop resources to support the application of genomics technologies to animal industries. I am delighted to see that the aims of this proposal include developing resources and support for genomic analyses; integrating this with other data types collected by the equine industry; and particularly your goal of linking with industry partners to help develop a data savvy workforce for US agriculture. These aims will more greatly support the objectives of the AQHA.

I look forward to working with State Agricultural Experiment Station personnel via continued engagement with researchers and through workshops, surveys, and community discussions.

We are excited about collaboratively working to enhance the future of agriculture genomics.

Sincerely,

Tammy Canida

Tammy Canida
AQHA Registrar

FENWAY FOUNDATION
FOR FRIESIAN HORSES

N3398 State Road 76
Hortonville, WI 54944

(888) 838-0877 | www.fenwayfoundation.com

July 12th, 2022

Dear Station Directors,

I am writing in support of the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries including the horse.

As the Education and Research Liaison at the Fenway Foundation for Friesian Horses, I have the responsibility of educating Friesian owners around the world and work closely with researchers to advance the knowledge Friesian horse genetics. The Fenway Foundation was founded in 2010 and was developed to improve the experience of both the Friesian Horse and their stewards. The focus of our foundation is Friesian horse rescue, genetic research, and education. As such, the proposal you are submitting supports the foundation's vision and mission to preserve and enhance the longevity and quality of life of Friesian Horses. We have long been committed to genetic studies for Friesian horses and we therefor enthusiastically support your proposal.

I understand the overall objective of this proposal is to develop resources that support the application of genomics technologies to animal industries. I am delighted to see that the aims of this proposal include developing resources and support for genomic analyses as this will be very important to future genetic research involving Friesian horses.

We look forward to working with State Agricultural Experiment Station personnel via continued engagement with researchers and their efforts in genetic studies and support of the Fenway Foundation's educational efforts.

The Fenway Foundation is excited about collaboratively working to improve or enhance the future of agriculture genomics.

Regards,

Angie DePuydt
Education & Research Liaison

FHANA
FRIESIAN HORSE ASSOCIATION
OF NORTH AMERICA

4037 Iron Works Parkway
Lexington, KY 40511

(859) 455-7430 | www.FHANA.com

July 11th, 2022

Dear Station Directors,

I am writing in support of the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries including the horse.

The Friesian Horse Association of North America (FHANA) is the sole representative in North American of the Koninklijke Vereniging 'Het Friesch Paarden-Stamboek' (KFPS). One of FHANA's strategic goals is to become an industry leader in Friesian genetic research and equine wellness by collaborating with other agencies, universities, and non-profits to support their research. As such, the proposal you are submitting is well in line with our mission to promote and preserve the KFPS Friesian Horse in North America. We have long been committed to genetic studies for our breed and we therefore enthusiastically support your proposal.

FHANA understands that the overall objective of this proposal is to develop resources that support the application of genomics technologies to animal industries. We are delighted to see that the aims of this proposal include developing resources and support for genomic analyses as this will be very important to future genetic research involving Friesian horses.

We look forward to working with State Agricultural Experiment Station personnel via continued engagement with researchers and their efforts in genetic studies and support of FHANA's educational events.

We are excited about collaboratively working to improve or enhance the future of agriculture genomics.

Regards,

Eric Smith

Eric Smith
FHANA President

The Jockey Club
821 Corporate Drive, Lexington, KY
40503 Phone: (859) 224-2700 | Fax:
(859) 224-2710

July 18, 2022

Dear Dr. Bellone and Station Directors,

I am writing in support of the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries including the horse.

As the Executive Vice President and Executive Director of the Jockey Club, I have the responsibility of working closely with our board of directors, those in the industry, and many researchers conducting work on the Thoroughbred. We fully support advancing the knowledge of genetics and genomics to best assist the horse industry and enable the breeding of healthy and durable horses. We have been using DNA testing since its inception for parentage exclusion in the early 1990s. This has been vital to maintaining the integrity of our breed. We have also supported research endeavors to best understand genetic variation in our breed and how specific variants impact health.

I understand that the overall objective of this proposal is to develop resources to support the application of genomics technologies to animal industries. I am delighted to see that the aims of this proposal include developing resources and support for genomic analyses and integrating this with other data types collected by the equine industry. I am also very pleased to see the focus on linking with industry partners to help develop a data savvy workforce for US agriculture. These aims also support the objectives of our organization.

I look forward to working with State Agricultural Experiment Station personnel via continued engagement with researchers and through workshops, internships and broader discussions with the Thoroughbred industry.

We are excited about collaboratively working to improve or enhance the future of agriculture genomics.

Kind Regards,

Matt Iuliano
Executive Vice President & Executive Director
The Jockey Club
859-224-2721 (o)
859-227-1879 (c)

Dedicated to the improvement of Thoroughbred breeding and racing for over a century

7/27/2022

Dear Station Directors,

I am writing in support of the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries.

By way of introduction, I am Director of Research and Development at Aviagen Turkeys Inc, a primary breeder supplying day old parent stock turkey poults to the global turkey industry. We continually invest in research and development to produce the best performing turkeys to meet our customers' needs and expectations.

Aviagen Turkeys utilizes a diverse range of genetic lines for development of its turkey breeds. In addition, it holds a large gene pool capable of meeting future needs. The company uses a balanced breeding goal, including health and fitness traits, alongside selection for key production traits such as reproduction, growth, feed conversion, and yield.

To achieve consistent improvement in performance and to select the best pedigree birds requires accurate measurement and comprehensive analysis of phenotypic and genetic data, which will allow Aviagen to develop healthy and efficient breeds of turkeys. I have been closely associated with the USDA-led animal genomics community over a number of years and look forward to a continued association with the opportunities and collaborations these can bring for turkey industry.

I understand that the overall objective of this proposal is to develop resources to support the application of genomics technologies to animal industries. The aims of this proposal include developing resources and support for genomic analyses; integrating this with other data types; and linking with industry partners to help develop a data savvy workforce for US agriculture. These aims will support primary breeders like Aviagen Turkeys by developing framework that may be used within breeding programs, as well as providing education and training for the next generation of geneticists to support animal agriculture in the US.

I look forward to working with State Agricultural Experiment Station personnel via workshops, community discussions and surveys, and training events.

We are excited about collaboratively working to improve the future of poultry genetics.

Aviagen Turkeys, Inc. • 31186 Midland Trail East • Lewisburg, West Virginia • U.S.A. • www.aviagenturkeys.com
Telephone: +1 304 793 2680 • Fax: +1 304 793 2684 • email: turkeysinc@aviagen.com

Regards,

Paige Rohlf
Research and Development Manager
Aviagen Turkeys Inc.

Hy-Line

Genetic Excellen

June 30, 2022

Dear Station Directors,

I am writing in support of the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries.

By way of introduction, I am the Molecular Geneticist at Hy-Line International. Hy-Line International is a primary poultry breeding company dedicated to the development and distribution of superior egg layer varieties. Hy-Line International layers can be found in over 110 countries and account for over 40% of the world-wide commercial egg production for both white and brown shell eggs. Hy-Line International was the first layer genetics company to establish an in-house molecular genetics laboratory in 1996. We continually invest in Research and Development to produce the best performing layers to meet our customers' needs and expectations. We incorporate genomic information into our breeding program on a commercial scale, and to use it to develop and improve our extensive gene pools.

I have been closely associated with the USDA-led animal genomics community for many years and continually utilize the multiple tools and resources developed by USDA in all aspects of my work. The many interactions with scientists supported by the State Agricultural Experiment Stations have been invaluable in advancing both the genomics and genetic applications at Hy-Line International. This is evidenced by the many collaborative publications involving Hy-Line and Experiment Station supported scientists.

I understand that the overall objective of this proposal is to develop resources to support the application of genomics technologies to animal industries. I understand that the aims of this proposal include developing resources and support for genomic analyses, integrating this with other data types, and linking with industry partners to help develop a data savvy workforce for US agriculture. These aims will support my company and my industry by providing training for the next generation of geneticists, developing additional tools that allow breeding companies to access the novel genomic information being developed and provide opportunities for strong and interactive collaborations between industry and academia. Both groups of scientists have access to unique resources, and by working together we can create considerable synergy.

I look forward to continuing to work with State Agricultural Experiment Station personnel via regional meetings, workshops and training events to continually improve the future applications of genomics in commercial breeding program.

Sincerely,

Janet Fulton

Janet Fulton
Senior Molecular Geneticist
Hy-Line International
Dallas Center, Iowa, USA

Superior Farms
AMERICAN LAMB

Dear Station Directors,

I am writing in support of the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries.

By way of introduction I am Karissa Isaacs, Director of Producer Resources for Superior Farms. Superior Farms is committed to providing leadership and a sustainable, successful future for the American lamb industry. As employee-owners, we are passionate about providing quality products and innovative solutions that delight consumers and exceed customer expectations.

We intend to use genetic data that can help commercial sheep producers increase productivity, efficiencies, and profitability. We are particularly interested in educational outreach and workshops to promote more effective applications of genetics and genomics for the sheep industry. Our industry needs to better understand the importance of genomics and the opportunities genetics and genomics can bring to an individual operations bottom line through genetic progress as well as the viability of the sheep industry in the U.S. as a whole by improving productivity.

I understand that the overall objective of this proposal is to develop resources to support the application of genomics technologies to animal industries. I understand that the aims of this proposal include developing resources and support for genomic analyses; integrating this with other data types collected by my industry; and linking with industry partners to help develop a data savvy workforce for US agriculture. These aims will promote the viability of the American Sheep Industry and Superior Farms by enhancing genetics and genomics of the American Sheep Industry and increase overall industry profitability.
I look forward to working with State Agricultural Experiment Station personnel through sheep genomic educational, workshops, industry discussions and trainings.

We are excited about collaboratively working to improve or enhance the future of agriculture genomics.

Regards,
Karissa Isaacs
Director of Producer Resources
Superior Farms
karissa.isaacs@superiorfarms.com

FOCUSED ON WHAT MATTERS.

September 29, 2022

Dear Station Directors,

I am writing in support of the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries.

By way of introduction, I am Tom Rathje and I work with DNA Genetics LLC, a swine breeding stock company. The mission of my company is to deliver improved swine genetics to the pork production industry. We use genetic data to select for and create improved performance in pig populations. We are particularly interested in more effective application of genetic and genomic data and applying large scale data to predict the behavior of complex agricultural systems. In addition, we are interested in training opportunities for our geneticists that will create new opportunities to apply this information.

I understand that the overall objective of this proposal is to develop resources to support the application of genomics technologies to animal industries. I understand that the aims of this proposal include developing resources and support for genomic analyses; integrating this with other data types collected by my industry; and linking with industry partners to help develop a data savvy workforce for US agriculture. These aims will support my company and the pork industry by providing the tools and talent required to continue to keep the production of pork highly sustainable and of benefit to people and our environment.

I look forward to working with State Agricultural Experiment Station personnel via workshops, providing internship opportunities, providing feedback through surveys and contributing to the ongoing engagement of stakeholders in these technologies.

We are excited about collaboratively working to improve and enhance the future of genomics applied to agriculture.

Regards,

Tom Rathje
Chief Technical Officer

402-564-0407 dnaswinegenetics.com 4438 Old Mill Court, Columbus, NE 68601

PIC USA, INC.
100 Bluegrass Commons Blvd. Ste. 2200
Hendersonville, TN 37075
Tel: 1-800-325-3398
www.PIC.com

September 30, 2022

Dear Station Directors,

I am writing in support of the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries.

By way of introduction I am Global Director of Product Development and Technical Services for PIC, the global market leader in swine genetics. The mission of my company is to continuously develop improved swine genetics for farmers around the globe enabling them to produce a safe and nutritious protein product with maximum efficiency and sustainability. We aggressively utilize genetic data to guide our understanding of the opportunities for targeted improvement in key traits of interest as well as provide information to swine producers to maximize their success with realizing these benefits in their operations. We are particularly interested in continuing to develop more effective applications to aid genetic improvement including advancing genomic data and genetic analysis. We believe it is essential to continue to support broad and engaged discussions involving diverse groups of academics and industry as these create opportunities to stimulate ideas, cascade progress and engage and train students which are needed for our industries to have the future talent necessary to remain competitive. We believe this proposal is well aligned with all of those initiatives and creates extra capacity for advancement.

I understand that the overall objective of this proposal is to develop resources to support the application of genomics technologies to animal industries and that the aims of this proposal include developing resources and support for genomic analyses; integrating this with other data types collected by my industry; and linking with industry partners to help develop a data savvy workforce for US agriculture. These aims will support my company/my industry by providing collaboration on solving current questions and needs and developing skills and talent for future development.

I look forward to working with State Agricultural Experiment Station personnel via the wide range of excellent work supported by this proposal.

We are excited about collaboratively working to improve or enhance the future of agriculture genomics.

Regards,

Matt Culbertson, PhD
Global Director
PIC

Smithfield
Good food. Responsibly.

200 Commerce Street
Smithfield, VA. 23430

Kent Gray
General Manager
Smithfield Premium Genetics

4134 US 117
Rose Hill, North Carolina, 28458

(910) 282-4227 x 24227 tel
kgray@smithfield.com

October 3rd, 2022

Dear Station Directors,

I am writing in support of the National Research Support Project (NRSP) proposal focused on developing the capacity to apply genomics-enabled technologies to animal industries.

By way of introduction, I am Kent Gray, the General Manager of Smithfield Premium Genetics, which supplies breeding stock and oversees the genetic program for Smithfield Foods, the largest pig producer and pork processor in the United States. We use genetic data to run internal breeding and selection programs. We are particularly interested in more effective applications of genetics and genomics data to increase our genetic gain and achieve success at the commercial level.

I understand that the overall objective of this proposal is to develop resources to support the application of genomics technologies to animal industries. I understand that the aims of this proposal include developing resources and support for genomic analyses; integrating this with other data types collected by our industry; and linking with industry partners to help develop a data-savvy workforce for US agriculture. These aims will support our industry by ensuring long-term growth and profitability for shareholders.

I look forward to working with State Agricultural Experiment Station personnel via internship and community discussion.

We are excited about collaboratively working to improve or enhance the future of agriculture genomics.
Regards,

Sincerely,

Kent Gray
General Manager
Smithfield Premium Genetics
kgray@smithfield.com

July 20, 2022

Dear Station Directors,

We are writing in support of the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries.

By way of introduction, we are the Director of Genetics Product Development (Genomics R&D) and former Agrigenomics Vice President and work for NEOGEN Corporation. The mission of our company is to ensure the safety of food production systems and specifically we work to empower genomic selection in animal protein production systems. We empower customers to use genomic data for augmenting pedigree relationships as well as selecting commercial animals which have inherited favorable versions of genes. As we look to deliver new genomic testing tools such as InfiniSEEK (low pass sequencing with imputation) to researchers and industry partners we are particularly interested in more effective applications of genetics and genomics data. Furthermore, we are also interested in applying large scale data to predict agricultural systems such as the outcomes of feedlot cattle.

We understand that the overall objective of this proposal is to develop resources to support the application of genomics technologies to animal industries. We also understand that the aims of this proposal include developing resources and support for genomic analyses; integrating this with other data types collected by our industry; and linking with industry partners to help develop a data savvy workforce for US agriculture. These aims will support our company by supporting development of best practices for using genomic data and creating new analytical models.

We look forward to working with State Agricultural Experiment Station personnel via workshops and community discussions.

We are excited about collaboratively working to improve or enhance the future of agriculture genomics.

Sincerely,

Rich Tait, Jr., Ph.D.
Director of Genetics Product Development
NEOGEN Genomics

Stewart Bauck, DVM, MS
Senior Director, Special Projects
NEOGEN Genomics

NEOGEN Genomics
4131 N 48th St. • Lincoln, NE 68504, USA
phone: 402.435.0665 • fax: 402.435.0664
geneseekinfo@neogen.com • www.genomics.neogen.com

recombinetics™

Dear Station Directors,

I am writing in support of the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries.

My name is Dan Carlson, Chief Scientific Officer of Recombinetics, gene editing and biotechnology company. The mission of my company is to lead the world in animal gene-editing for healthier people, healthier animals and a healthier planet. We use genetic and phenotypic data to identify high impact traits that can be delivered to livestock using gene editing technology. We are particularly interested in applying large scale data to predict agricultural systems, and to identify natural, beneficial gene variants that are absent or underrepresented in target animal populations.

I understand that the overall objective of this proposal is to develop resources to support the application of genomics technologies to animal industries. I understand that the aims of this proposal include developing resources and support for genomic analyses; integrating this with other data types collected by my industry; and linking with industry partners to help develop a data savvy workforce for US agriculture. These aims will support my company/my industry by creating a hub for genomic data that can be analyzed by our scientist to develop new traits.

I look forward to working with State Agricultural Experiment Station personnel via workshops and community discussions. Collaboration of this sort is not only critical our mission and will help improve the future of agriculture genomics.

Regards,

Daniel Carlson

Daniel F. Carlson, PhD
Chief Scientific Officer
Recombinetics

3388 Mike Collins Drive, Suite 1, Eagan, MN 55121
recombinetics.com

STgenetics®

Dear Station Directors,

I am writing in support of the National Research Support Project (NRSP) proposal focused on developing capacity to apply genomics-enabled technologies to animal industries.

By way of introduction I am Joseph Deeb, Technical Director of Genetics and Genomics at STgenetics. STgen is a leader in applying cutting-edge technology to animal breeding. The mission of my company is to lead a global transformation in the production of more efficient, healthy, and environmentally responsible food animal protein. We use genetic and genomics data to support the Dairy, Beef and Pig industries to produce more efficient, sustainable, and healthier animals. Among many other things, we are particularly interested in improving the efficiency in which animals utilize nutrients and reduce the impact of our industries on the environment. We are utilizing high-density genotyping and whole-genome sequencing to improve on the accuracy of genomic predictions and to better understand the underlying molecular mechanisms controlling economically important traits.

I understand that the overall objective of this proposal is to develop resources to support the application of genomics technologies to animal industries. I understand that the aims of this proposal include developing resources and support for genomic analyses; integrating this with other data types collected by my industry; and linking with industry partners to help develop a data savvy workforce for US agriculture. These aims will support my company by providing better platforms to optimize the use of data collected across the industry and assist is maximizing the use of new genomic tools and technologies to increase the rate of genetic improvement.

I look forward to working with State Agricultural Experiment Station personnel via participating in workshops, discussions and training events or other ways that might contribute to the program.

We are excited about collaboratively working to improve or enhance the future of agriculture genomics.
Regards,

Joseph Deeb, PhD.
Technical Director of Genetics and Genomics
STgenetics
22575 Highway 6 South
Navasota, Texas 77868
email: jdeeb@stgen.com
mobile: (270) 776-4011
Office: (936) 870-3960 ext. 181

Joseph Deeb

NAME

10/03/2022

Date

NRSP Review (Submitted)

Project: National Animal Genome Research Program

Dates Covered

10/01/2023 - 09/30/2028

The following statement defines the mission of the National Research Support Projects (NRSP's):

NRSP Mission: National Research Support Projects (NRSPs) focus on the development of enabling and critical technologies (e.g., databases, cyberinfrastructure, on-line toolkits, reagents), support activities (e.g., collect, assemble, store, and distribute materials, data, resources or information) or the sharing of facilities (e.g., analytical equipment, lab, field) needed to accomplish high priority research.

Based on this mission, please rate the proposed NRSP using the following criteria.

	Satisfactory	Unsatisfactory
Mission:		
Consistency with the NRSP mission	◉	○
Relevance:		
Addresses and supports a high priority national issue	◉	○
Demonstrates clear and tangible benefits to the scientific community as a whole	◉	○
Clearly identified sponsoring beneficiary stakeholders	◉	○
Stakeholder involvement in project development, project activities, review, and/or management plans	◉	○
Technical Merit:		
Overall technical merit (sound scientific approach, achievable objectives, review, and/or management plans	◉	○
Potential for significant outputs (products) and outcomes with impacts	◉	○
Implementation Plan:		
Benchmarks for success clearly identified	◉	○
Management structure that adequately coordinates efforts of multiple participants	◉	○
Well-developed business plan that captures multiple sources of funding and leverages OTT MRF	◉	○
Funding plan that develops alternative funding sources to reduce OTT MRF in future years	◉	○
Efforts integrated with Extension, academic, or international programs	◉	○
Outreach, communications and assessment plan that communicates the program goals, accomplishments, and outcomes, and impacts	◉	○

Comments (Please add general and specific comments on strengths and weaknesses of the proposal, including specific revisions that would improve the proposal):

Overall Recommendation:

Approve

NRSP_TEMP_11: Building Collaborative Research Networks to Advance the Science of Soil Fertility: Fertilizer Recommendation Support Tool (FRST)

Status: Draft Project

Duration	10/01/2023 to 09/30/2028
Admin Advisors:	[Gary Pierzynski] [Nathan A Slaton] [Eric P Webster]
NIFA Reps:	

Statement of Issues and Justification

Prerequisite Criteria

How is the NRSP consistent with the mission?

Statement of Issues and Justification: Soil testing and the recommendations derived from laboratory analyses provide the backbone for nutrient management in modern agricultural production systems. However, most science-based soil fertility recommendation systems for phosphorus (P) and potassium (K) fertilizer guidance are based on decades-old soil-test relationships that were developed within states in the 1950s-1970s (Spargo et al., 2022). While soil testing has the common goal of determining which nutrients are needed and how much fertilizer to apply, soil-testing laboratories in the U.S. use different analytical methods, interpretations, and philosophical approaches when making fertilizer or nutrient recommendations. The NIFA soil test regional work groups (NCERA-13, NECC-1012, SERA-6, and WERA-103) have provided good guidance for analytical methods and today, five soil test extractants are used to analyze P and/or K of most soil samples in the USA (Spargo et al., 2022). Additionally, all university labs participate in either the North American Proficiency Testing (NAPT) Program or the Agricultural Lab Proficiency (ALP) Program to assure the accuracy and precision of soil test results. Thus, the differences in soil-test-based nutrient recommendations among labs across states with similar physiographic areas and soils are most often due to older calibration and correlation study results and interpretations of the results (e.g. philosophical choices).

Conflicting and outdated recommendations across state boundaries lead to end-user confusion and reduced confidence in soil testing, which ultimately proves detrimental to research and educational efforts that encourage 4R Nutrient Stewardship. The 4R Nutrient Stewardship program is the backbone of USDA-NRCS Nutrient Management Standard designed to optimize nutrient use while minimizing off-site impact of nutrients on water quality. Despite long-standing regional efforts to maintain communication and coordination across soil testing programs, Zhang et al. (2020) demonstrated that land grant recommendations from university or state labs within the Southern region using the same soil test extractants had P recommendations that varied by a factor of 2.5. These differences across state lines were primarily based on best professional judgment rather than empirical evidence. Scientifically defensible soil-test recommendations are fundamental to agricultural production and environmental protection.

To advance the precision of soil test recommendations and, where appropriate, dissociate them from state boundaries, we developed the Modernizing Fertilizer Recommendations: Fertilizer Recommendation Support Tool, or “FRST”, project, which we believe is foundational to farmers and nutrient management conservation efforts nationwide. By optimizing nutrient use and decreasing nutrients at the source, and thereby increasing the effectiveness of conservation practices, both farmers and taxpayers will save millions of dollars annually and protect the environment by reducing off-site nutrient loss. While the responsibility of interpreting soil test results and developing recommendations will remain with land-grant soil fertility faculty of each state, FRST aims to stimulate cooperation among states and across regions, providing valuable data and resources for up-to-date and science-based fertilizer recommendation systems, including standardizing the equations for the relative yield value and critical soil test value, in order to reduce differences in recommendation philosophies.

State-based, soil-test correlation databases seldom have enough site-years and diversity to develop recommendations based on factors other than soil-test P or K. Development of the national soil-test correlation database for legacy, current, and future research results will be instrumental in developing recommendations that consider covariates that can make nutrient recommendations specific for production systems with different crop yield potentials, soil properties that influence nutrient availability (e.g., soil pH and clay content), and factors like drainage and slope that influence nutrient movement. It is possible that analysis of the large, diverse database may show that soil test critical nutrient values and the resulting fertilizer-nutrient rate recommendations should be different among geographic regions.

Standardization of soil-test-based nutrient use recommendations is one possible outcome when data from multiple states are analyzed together, but standardization of recommendations is not the end goal of this project. The most important outcomes of the FRST Project are making soil-test-based fertilizer recommendations more scientifically defensible and more accurate, increasing end-user confidence in fertilizer recommendations, and developing a consistent soil-testing vocabulary and with clear definitions of the term used in the soil-testing industry. All of these goals require extensive research to analyze data and open conversations with all stakeholders and industry segments to develop a consensus and seek out all educational opportunities to disseminate the information.

How does the NRSP pertain as a national issue?

Rationale

Priority Established by ESCOP/ESS

The **primary goal** of FRST is to address the national issue of soil testing transparency and accuracy by promoting clear and consistent interpretations of fertilizer recommendations by removing political and institutional (public and private) bias from soil test interpretation and providing the best possible science to enhance end-user adoption of nutrient management recommendations. A **secondary goal** is to provide a catalyst for innovation in soil fertility – useful to those making recommendations as well as those evaluating those recommendations.

The FRST project has been in existence for four years and follows an activity-based program. The activities have varied end points, which will be listed here. Some of them have been completed while others will be ongoing for the life of the national project.

Every activity proposed in the FRST project has been assessed based on the outcomes we established. For instance, the minimum dataset was considered successful when the journal article was published, the data entry template for the FRST tool was developed and placed at soiltestfrst.org, and the minimum dataset was used for state-level soil test correlation and calibration trials. Completion of identified details within the activities is important to the collaborators and the success of this project. The executive team meets bi-weekly to assess each activity and ensure that timelines and deliverables are being met. The outcome of all objectives and activities are assessed by participant involvement and the publication and citation of fact sheets and peer-reviewed journal papers. (See section C for more details on the executive team.)

Relevance to Stakeholders

We have two primary stakeholder groups: the soil fertility research community and agricultural practitioners, such as producers, certified crop advisors (CCAs), fertilizer dealers, etc. The soil fertility community, both researchers at land grant universities and USDA-ARS, as well as practitioners in the federal government, primarily NRCS, are our soil fertility research community stakeholders. The farming community will be both primary and secondary stakeholders, as they will not only have direct access to the FRST tool, but will also benefit from improved fertilizer recommendations developed by the research community supported by FRST. USDA-NRCS 590 Nutrient Management Standard is foundational to conservation practices and FRST should support a more robust 590 standard to optimize nutrients for the producer while minimizing the off-site environmental impact.

As mentioned, the soil fertility research community is actively involved in monthly meetings, current activities, and proposing new activities. By forming a community of practice, we are increasing the knowledge of the collaborators and working on research topics of interest to many. When the database is sufficiently robust, we will allow the research community to access the data for further exploration of soil test correlation and calibration trials. Access to the database will support work by many types of researchers and extension scientists, beyond soil fertility, such as crop physiologists, agro climatologists and modelers. The minimum dataset will ensure that the database is populated with all relevant data that could be used to further the investigation of topics around soil fertility, including soil texture, soil sampling depth, and other environmental parameters (Slaton et al., 2021).

Once there is a beta version of the FRST decision tool, our stakeholder community expands to include additional users – farmers, CCAs, private soil test laboratory professionals, and others. We have begun to interact with the private soil test laboratory professionals, who are eager to participate and believe this will help the credibility of recommendations. We will solicit participation from these groups to provide feedback and suggestions regarding the functioning of the tool and the usefulness of the output. This will be a highly interactive process.

Implementation

Objectives

1. Develop a community of practice to galvanize interest and participation around soil fertility.
2. Develop a searchable tool that provides soil test correlation and calibration graphs with statistical confidence intervals for the geographic area(s) of interest (general users). The first step will be to identify the critical soil test level above which there is no response (correlation) and the next step will be to provide fertilizer-nutrient rate recommendations when a yield response from fertilization is expected (calibration).
3. Provide data to nutrient management scientists and modelers for in-depth analysis of soil test correlation and calibration data (researchers).

Projected Outcomes

- Soil fertility faculty at land grant universities were surveyed on current soil fertility practices and recommendations to better understand the status of soil testing across the U.S. and identify opportunities to harmonize nutrient management guidelines. Comments: The survey and all data have been published in Ag Data Commons (National Ag Library; Spargo et al., 2022). A synthesis paper has been written and submitted for publication. There are many other papers that can be developed from the national survey data by whichever collaborators want to work on them. Finally, the data are being shared with stakeholders, such as NRCS, to help them understand how underfunded soil test correlation and calibration has been in the U.S during the past 40 to 50 years.
- Developed, with a team of land grant soil fertility faculty, a minimum dataset for future correlation and calibration trials to guide research in the U.S. Comments: After two years of frequent meetings, the minimum data set for soil test correlation and calibration trials was published (Slaton et al., 2021) and an Excel spreadsheet template developed that allows researchers to easily capture the necessary data that meets the minimum data requirements. Data for FRST will be spooled from the minimum dataset to the Excel file into the relational database.
- Development of the FRST database to preserve legacy data and add new soil test correlation and calibration P and K data. Comments: The database was developed in Excel then transformed to a relational database structure that includes the legacy data as well as the minimum data set components. The database is a product that will be tied to the FRST decision tool (Lyons et al., 2021). Data will continue to be collected and added to the database over the life of the project. We anticipate that the database will be used extensively by researchers to model and publish soil test correlation results.
- Explored and determined the most appropriate relative yield calculation for use in the FRST decision support tool by a group of FRST collaborators who volunteered. Comments: This was a new activity proposed by the collaborators. After a year of work by the committee, there was consensus around the equation selected for the relative yield calculation, which will be used in the FRST tool. In addition, a journal article was written as there was no literature comparing different relative yield definitions with each other (Pearce et al., 2022).
- Supported state-level soil test correlation and calibration trials during 2021 funded by FRST. Comments: The data derived from these soil test correlation and calibration trials (18) were delivered and entered into the FRST database. A number of these trials also received Ag Data Commons citations (https://soiltestfrst.org/resources/). We will continue to encourage trials as we have resources available.
- Developing a multi-state analysis of soil sampling depth influence on soil test outcomes to translate between different soil depths. Comments: Different states and cropping systems utilize different soil sampling depths. As there was no peer-reviewed publication providing translation soil test values between depths regionally, we began this work during 2021. Scientists from over two-thirds of land grant universities in the U.S. have participated in this study with a total of 2936 samples from 197 unique sites. The protocol was very rigorous and was vetted and approved by all collaborators. Multiple depths were collected, and the soil was analyzed for Mehlich-3 extractable nutrients, pH, organic matter and depending on the geographical location from which it was collected, also Olsen P (western states with pH > 7.2) or Modified Morgan P (northeastern states). Collaborators also provided metadata to be able to associate cropping systems and soil characteristics, including texture, with the depth translation. The data are currently being analyzed. The output from this activity will provide translation equations for soils under various cropping systems at different sampling depths in the FRST decision tool. Therefore, we expect multiple translation equations relative to the system and depth sampled.
- Selecting the soil test correlation model appropriate for determining the critical soil test value is essential for the FRST decision tool. Comments: As there are several available models, it is important to consider their strengths and weaknesses, analyze them statistically, and then determine the appropriate model for use in the FRST decision tool. FRST collaborators volunteered to work on this very important committee and after approximately one year of work, the committee selected.
- Development of a user-friendly decision support tool to provide soil test user information for a soil-test and crop-response-to-fertilization searchable web-based decision tool. Comments: The output from the tool is the ultimate goal of the project. Users, which include the private sector (e.g. soil test labs, CCAs, etc), will be enlisted to help beta-test the FRST decision tool. Discussions are already underway with a large association of private soil test labs.

Management, Budget and Business Plan

Management, Budget, and Business Plan: The FRST project has a nine-person executive team composed initially of a self-forming group that volunteered when this project was established. More recently there have been changes in the composition of the group. There are five faculty (professors from NC State, Penn State, University of Arkansas, University of Minnesota, and Utah State University), one ARS researcher, one data scientist/programmer (NC State), and one research scholar. Dr. John Spargo from Penn State represents the Northeastern region (NECC-1012), Drs. Deanna Osmond (NC State University) and Nathan Slaton (University of AR) represent the Southern region (SERA-6), Dr. Dan Kaiser (University of MN) represents the North Central region (NCERA-13), while Dr. Matt Yost (Utah State University) represents the Western and Mountain regions (WERA-103). Drs. Kleinman and Osmond represent SERA-17. As representatives from WERA-103 and NCERA-13 are newly added, those organizations will determine who and how representatives are rotated onto and off the executive team, but their tenure must be a minimum of two years. Penn State will continue to represent NECC-1012, which is a very small group, and the SERA-6 representatives will continue as the FRST project started in that region and anyone that wanted to serve could volunteer. The executive committee meets twice a month to ensure the timely completion of current activities. They also discuss new funding and activity opportunities and different management components as they arise.

Budget

The project is currently funded by USDA-NRCS through March 2024, with the spending categories provided below. This will represent four years of funding and we had an additional three years of prior funding from USDA-ARS that overlapped with NRCS funding, which paid for one each post-doctoral and research scholar salaries. The post-doctoral associate, Dr. Austin Pearce, who left in October 2022, led the activities to determine the relative yield definition and the critical soil test value model. The research scholar, Dr. Sarah Lyons, developed the Excel database as she curated and added legacy data. She also has worked on data configuration for the survey data and provided support for colleagues submitting data to Ag Data Commons for publication. She will continue this activity as collaborators ask. The programmer has developed the relational database and is programming the FRST decision tool. Supplies and materials are primarily for computers and other necessary software costs. Current services have paid for state-level soil test correlation and calibration trials (2021) and laboratory costs associated with the soil depth translation project. Journal publications are also charged to Current Services. Travel has and will pay for travel to scientific meetings for those presenting information on FRST.

USDA-NRCS Description (April 2020-March 2024)	**Current Budget**
EHRA Non-Teaching Salaries	487,404.00
Staff Benefits	149,714.00
Total Personnel Expenditures	**$637,118.00**
Contracted Services	1,000.00
Supplies and Materials	13,091.00
Travel-Domestic	50,882.00
Current Services	204,000.00
Total Direct Costs	**$909,091.00**
Total Indirect Costs	$90,909.00
Total Expenditures	**$1,000,000.00**

Since application to the NRSP is for five years, we will use resources provided by NRCS for the next two years, while we continue to try to find resources from federal agencies, not-for-profit organizations, and corporations. We are also asking for NRSP funding of $212,000 ($70,667 per year) from 2024-2027 as follows:

NRSP Description (2024-2027)	Current Budget
SHRA Non-Teaching Salaries	150,000
Staff Benefits	50,000
Total Personnel Expenditures	**200,000**
Current Services	12,000
Total Expenditures	**212,000**

The funding for salaries will pay for a part-time programmer for the FRST decision tool and current services will pay for journal publication (two per year). We recognize that NRSP funding is not on-going and we will continue to look for funding from both the public and private sectors, as we have continued to do throughout the life of the project.

Integration

By its very nature, the FRST project is well-integrated. Many collaborators maintain a mixture of extension, research, and/or teaching appointments. The development of the FRST tool is based on research, some of which has been performed during this project, but the execution of the decision tool is an applied outreach tool. Expectations are that faculty will include some of the published work from FRST into class discussion; for instance, inclusion of the Minimum Dataset paper, to provide guidance on best practice in soil correlation and calibration trials, would be an excellent teaching tool for a graduate-level soil fertility course. Demonstrations of the FRST tool would also be an excellent source of material for extension outreach and presentations, and could provide valuable material to an international audience for similar projects to take place worldwide.

Outreach, Communications and Assessment

Because FRST is heavily skewed by many extension specialists that are part of the project, extension was baked into the project from the beginning. The elements expected for this project are described below.

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Land Grant Participating States/Institutions

Non Land Grant Participating States/Institutions

Participation

Participant	Is Head	Station	Objective	Research						Extension	
				KA	SOI	FOS	SY	PY	TY	FTE	KA

Combined Participation

Combination of KA, SOI and FOS	Total SY	Total PY	Total TY
Grand Total:	**0**	**0**	**0**

Program/KA	Total FTE
Grand FTE Total:	0

Budgets

MRF Funding 2023

Description	Dollars	FTE
Salaries	200000.00	0.00
Fringe Benefits	0.00	0.00
Wages	0.00	0.00
Travel	0.00	0.00
Supplies	0.00	0.00
Maintenance	0.00	0.00
Equipment / Capital Improvement	0.00	0.00
Other	12000.00	0.00
Totals	**212000**	**0**

Comments

MRF Funding 2024

Description	Dollars	FTE
Salaries	200000.00	0.00
Fringe Benefits	0.00	0.00
Wages	0.00	0.00
Travel	0.00	0.00
Supplies	0.00	0.00
Maintenance	0.00	0.00
Equipment / Capital Improvement	0.00	0.00
Other	12000.00	0.00
Totals	**212000**	**0**

Comments

MRF Funding 2025

Description	Dollars	FTE
Salaries	200000.00	0.00
Fringe Benefits	0.00	0.00
Wages	0.00	0.00
Travel	0.00	0.00
Supplies	0.00	0.00
Maintenance	0.00	0.00
Equipment / Capital Improvement	0.00	0.00
Other	12000.00	0.00
Totals	**212000**	**0**

Comments

MRF Funding 2026

Description	Dollars	FTE
Salaries	200000.00	0.00
Fringe Benefits	0.00	0.00
Wages	0.00	0.00
Travel	0.00	0.00
Supplies	0.00	0.00
Maintenance	0.00	0.00
Equipment / Capital Improvement	0.00	0.00
Other	12000.00	0.00
Totals	**212000**	**0**

Comments

MRF Funding 2027

Description	Dollars	FTE
Salaries	200000.00	0.00
Fringe Benefits	0.00	0.00
Wages	0.00	0.00
Travel	0.00	0.00
Supplies	0.00	0.00
Maintenance	0.00	0.00
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Other	12000.00	0.00
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Comments

Building Collaborative Research Networks to Advance the Science of Soil Fertility:

Fertilizer Recommendation Support Tool (FRST)

A. *Statement of Issues and Justification:* Soil testing and the recommendations derived from laboratory analyses provide the backbone for nutrient management in modern agricultural production systems. However, most science-based soil fertility recommendation systems for phosphorus (P) and potassium (K) fertilizer guidance are based on decades-old soil-test relationships that were developed within states in the 1950s-1970s (Spargo et al., 2022). While soil testing has the common goal of determining which nutrients are needed and how much fertilizer to apply, soil-testing laboratories in the U.S. use different analytical methods, interpretations, and philosophical approaches when making fertilizer or nutrient recommendations. The NIFA soil test regional work groups (NCERA-13, NECC-1012, SERA-6, and WERA-103) have provided good guidance for analytical methods and today, five soil test extractants are used to analyze P and/or K of most soil samples in the USA (Spargo et al., 2022). Additionally, all university labs participate in either the North American Proficiency Testing (NAPT) Program or the Agricultural Lab Proficiency (ALP) Program to assure the accuracy and precision of soil test results. Thus, the differences in soil-test-based nutrient recommendations among labs across states with similar physiographic areas and soils are most often due to older calibration and correlation study results and interpretations of the results (e.g. philosophical choices).

Conflicting and outdated recommendations across state boundaries lead to end-user confusion and reduced confidence in soil testing, which ultimately proves detrimental to research and educational efforts that encourage 4R Nutrient Stewardship. The 4R Nutrient Stewardship program is the backbone of USDA-NRCS Nutrient Management Standard designed to optimize nutrient use while minimizing off-site impact of nutrients on water quality. Despite long-standing regional efforts to maintain communication and coordination across soil testing programs, Zhang et al. (2020) demonstrated that land grant recommendations from university or state labs within the Southern region using the same soil test extractants had P recommendations that varied by a factor of 2.5. These differences across state lines were primarily based on best professional judgment rather than empirical evidence. Scientifically defensible soil-test recommendations are fundamental to agricultural production and environmental protection.

To advance the precision of soil test recommendations and, where appropriate, dissociate them from state boundaries, we developed the Modernizing Fertilizer Recommendations: Fertilizer Recommendation Support Tool, or “FRST”, project, which we believe is foundational to farmers and nutrient management conservation efforts nationwide. By optimizing nutrient use and decreasing nutrients at the source, and thereby increasing the effectiveness of conservation practices, both farmers and taxpayers will save millions of dollars annually and protect the environment by reducing off-site nutrient loss. While the responsibility of interpreting soil test results and developing recommendations will remain with land-grant soil fertility faculty of each state, FRST aims to stimulate cooperation among states and across regions, providing valuable data and resources for up-to-date and science-based fertilizer recommendation systems, including standardizing the equations for the relative yield value and critical soil test value, in order to reduce differences in recommendation philosophies.

State-based, soil-test correlation databases seldom have enough site-years and diversity to develop recommendations based on factors other than soil-test P or K. Development of the national soil-test correlation database for legacy, current, and future research results will be instrumental in developing recommendations that consider covariates that can make nutrient recommendations specific for production systems with different crop yield potentials, soil properties that influence nutrient availability (e.g., soil pH and clay content), and factors like drainage and slope that influence nutrient movement. It is possible that analysis of the large, diverse database may show that soil test critical nutrient values and the resulting fertilizer-nutrient rate recommendations should be different among geographic regions.

Standardization of soil-test-based nutrient use recommendations is one possible outcome when data from multiple states are analyzed together, but standardization of recommendations is not the end goal of this project. The most important outcomes of the FRST Project are making soil-test-based fertilizer recommendations more scientifically defensible and more accurate, increasing end-user confidence in fertilizer recommendations, and developing a consistent soil-testing vocabulary and with clear definitions of the term used in the soil-testing industry. All of these goals require extensive research to analyze data and open conversations with all stakeholders and industry segments to develop a consensus and seek out all educational opportunities to disseminate the information.

The FRST project is composed of over 100 individuals representing 41 land-grant (40 states and one territory), two state universities, one private university, three USDA divisions (Agricultural Research Service, Natural Resources Conservation Service and Farm Service Agency), three not-for-profit organizations, and one State Department of Agriculture. The collaborative nature of the FRST project is at its core. Many of the FRST collaborators are members of one of the four existing multi-state soil testing projects: NCERA-13, NECC-1012, SERA-6, and WERA-103. Additionally, SERA-17 has been engaged in the FRST effort. The need for a national project like FRST was discussed at a joint meeting of the Regional Soil Testing Multi-state groups held at Penn State (July 2016).

There are eight FRST activities leading to the development of the FRST decision tool that will initially provide critical soil test values based on selected parameters such as region, soil classification, crop, and other metadata. Longer-term, the FRST tool will provide recommendations, again based on user criteria selection.

Activities include:

1) Surveyed soil fertility faculty at land grant universities on current soil fertility practices and recommendations to better understand the current status of soil testing across the U.S. and identify opportunities to harmonize nutrient management guidelines (Spargo et al., 2022);

2) A team of land grant soil fertility faculty developed a minimum dataset for future soil test correlation and calibration trials to guide research in the U.S. (Slaton et al., 2021);

3) Developed the FRST database to preserve legacy data and add new soil test correlation and calibration P and K data (Lyons et al., 2021);

4) Explored and determined the most appropriate relative yield calculation for use in the FRST decision support tool (Pearce et al., 2022);

5) Supported state-level soil test correlation and calibration trials during 2021 funded by FRST;

6) Developing a multi-state analysis of soil sampling depth influence on soil test outcomes in order to translate between different soil depths;

7) Determined the soil test correlation model most appropriate for the FRST decision tool (Pearson et al., 2022 in review), and;

8) Developing a user-friendly decision support tool to provide soil test user information for a soil-test and crop-response-to-fertilization searchable web-based decision tool. This tool will provide more consistent, transparent, and science-based decisions for nutrient recommendations.

Activities 2, 4 and 5 have been completed, while activity 1 and 7 are almost complete. We have started activities 6. Activity 3 and 8 will be ongoing during the life of the project and require long-term support for the success of this initiative.

Project activities are not fixed. Some activities were started at the beginning of the project while others began through collaborator group discussions around specific topics, such as the appropriate definition for relative yield. Other activities have been added as individual interest has aligned with need, like a sub-committee looking into updating lime recommendations. A new activity suggested by faculty collaborators is to compare P and K nutrient recommendations within the Western and Mountain regions similar to what a southern regional group did (Zhang et al., 2020). Another suggestion was to possibly add sulfur to the database. We expect new activities to be suggested from collaborators, accepted or declined based on need and funding, and if accepted, brought to fruition. The large collaborator group allows for new activities to be nominated and added as resources allow.

We have two primary stakeholder groups: the soil fertility research community and agricultural practitioners, such as producers, certified crop advisors (CCAs), fertilizer dealers, etc. The soil fertility community, both researchers at land grant universities and USDA-ARS, as well as practitioners in the federal government, primarily NRCS, are our soil fertility research community stakeholders. The farming community will be both primary and secondary stakeholders, as they will not only have direct access to the FRST tool, but will also benefit from improved fertilizer recommendations developed by the research community supported by FRST. USDA-NRCS 590 Nutrient Management Standard is foundational to conservation practices and FRST should support a more robust 590 standard to optimize nutrients for the producer while minimizing the off-site environmental impact.

As mentioned, the soil fertility research community is actively involved in monthly meetings, current activities, and proposing new activities. By forming a community of practice, we are increasing the knowledge of the collaborators and working on research topics of interest to many. When the database is sufficiently robust, we will allow the research community to access the data for further exploration of soil test correlation and calibration trials. Access to the database will support work by many types of researchers and extension scientists, beyond soil fertility, such as crop physiologists, agro climatologists and modelers. The minimum dataset will

ensure that the database is populated with all relevant data that could be used to further the investigation of topics around soil fertility, including soil texture, soil sampling depth, and other environmental parameters (Slaton et al., 2021).

Once there is a beta version of the FRST decision tool, our stakeholder community expands to include additional users – farmers, CCAs, private soil test laboratory professionals, and others. We have begun to interact with the private soil test laboratory professionals, who are eager to participate and believe this will help the credibility of recommendations. We will solicit participation from these groups to provide feedback and suggestions regarding the functioning of the tool and the usefulness of the output. This will be a highly interactive process.

***B. Objectives and Projected Outcomes**:*

Goals

The **primary goal** of FRST is to address the national issue of soil testing transparency and accuracy by promoting clear and consistent interpretations of fertilizer recommendations by removing political and institutional (public and private) bias from soil test interpretation and providing the best possible science to enhance end-user adoption of nutrient management recommendations. A **secondary goal** is to provide a catalyst for innovation in soil fertility – useful to those making recommendations as well as those evaluating those recommendations.

Objectives

The primary objectives of the FRST project that the National Research Support Program (NRSP) funding will support are as follows:

1. Develop a community of practice to galvanize interest and participation around soil fertility.
2. Develop a searchable tool that provides soil test correlation and calibration graphs with statistical confidence intervals for the geographic area(s) of interest (general users). The first step will be to identify the critical soil test level above which there is no response (correlation) and the next step will be to provide fertilizer-nutrient rate recommendations when a yield response from fertilization is expected (calibration).
3. Provide data to nutrient management scientists and modelers for in-depth analysis of soil test correlation and calibration data (researchers).

The FRST project has been in existence for four years and follows an activity-based program. The activities have varied end points, which will be listed here. Some of them have been completed while others will be ongoing for the life of the national project.

1) Soil fertility faculty at land grant universities were surveyed on current soil fertility practices and recommendations to better understand the status of soil testing across the U.S. and identify opportunities to harmonize nutrient management guidelines. The survey and all data have been published in Ag Data Commons (National Ag Library; Spargo et al., 2022). A synthesis paper has been written and submitted for publication. There are many other papers that can be developed from the national survey data by whichever collaborators want to work on them. Finally, the data are being shared with stakeholders, such as NRCS, to help them understand how

underfunded soil test correlation and calibration has been in the U.S during the past 40 to 50 years.

2) Developed, with a team of land grant soil fertility faculty, a minimum dataset for future correlation and calibration trials to guide research in the U.S. After two years of frequent meetings, the minimum data set for soil test correlation and calibration trials was published (Slaton et al., 2021) and an Excel spreadsheet template developed that allows researchers to easily capture the necessary data that meets the minimum data requirements. Data for FRST will be spooled from the minimum dataset to the Excel file into the relational database.

3) Development of the FRST database to preserve legacy data and add new soil test correlation and calibration P and K data. The database was developed in Excel then transformed to a relational database structure that includes the legacy data as well as the minimum data set components. The database is a product that will be tied to the FRST decision tool (Lyons et al., 2021). Data will continue to be collected and added to the database over the life of the project. We anticipate that the database will be used extensively by researchers to model and publish soil test correlation results.

4) Explored and determined the most appropriate relative yield calculation for use in the FRST decision support tool by a group of FRST collaborators who volunteered. This was a new activity proposed by the collaborators. After a year of work by the committee, there was consensus around the equation selected for the relative yield calculation, which will be used in the FRST tool. In addition, a journal article was written as there was no literature comparing different relative yield definitions with each other (Pearce et al., 2022).

5) Supported state-level soil test correlation and calibration trials during 2021 funded by FRST. The data derived from these soil test correlation and calibration trials (18) were delivered and entered into the FRST database. A number of these trials also received Ag Data Commons citations (https://soiltestfrst.org/resources/). We will continue to encourage trials as we have resources available.

6) Developing a multi-state analysis of soil sampling depth influence on soil test outcomes to translate between different soil depths. Different states and cropping systems utilize different soil sampling depths. As there was no peer-reviewed publication providing translation soil test values between depths regionally, we began this work during 2021. Scientists from over two-thirds of land grant universities in the U.S. have participated in this study with a total of 2936 samples from 197 unique sites. The protocol was very rigorous and was vetted and approved by all collaborators. Multiple depths were collected, and the soil was analyzed for Mehlich-3 extractable nutrients, pH, organic matter and depending on the geographical location from which it was collected, also Olsen P (western states with pH $\geq$ 7.2) or Modified Morgan P (northeastern states). Collaborators also provided metadata to be able to associate cropping systems and soil characteristics, including texture, with the depth translation. The data are currently being analyzed. The output from this activity will provide translation equations for soils under various cropping systems at different sampling depths in the FRST decision tool. Therefore, we expect multiple translation equations relative to the system and depth sampled.

7) Selecting the soil test correlation model appropriate for determining the critical soil test value is essential for the FRST decision tool. As there are several available models, it is important to consider their strengths and weaknesses, analyze them statistically, and then determine the appropriate model for use in the FRST decision tool. FRST collaborators volunteered to work on this very important committee and after approximately one year of work, the committee selected

8) Development of a user-friendly decision support tool to provide soil test user information for a soil-test and crop-response-to-fertilization searchable web-based decision tool. The output from the tool is the ultimate goal of the project. Users, which include the private sector (e.g. soil test labs, CCAs, etc), will be enlisted to help beta-test the FRST decision tool. Discussions are already underway with a large association of private soil test labs.

Every activity proposed in the FRST project has been assessed based on the outcomes we established. For instance, the minimum dataset was considered successful when the journal article was published, the data entry template for the FRST tool was developed and placed at soiltestfrst.org, and the minimum dataset was used for state-level soil test correlation and calibration trials. Completion of identified details within the activities is important to the collaborators and the success of this project. The executive team meets bi-weekly to assess each activity and ensure that timelines and deliverables are being met. The outcome of all objectives and activities are assessed by participant involvement and the publication and citation of fact sheets and peer-reviewed journal papers. (See section C for more details on the executive team.)

C. Management, Budget, and Business Plan*:* The FRST project has a nine-person executive team composed initially of a self-forming group that volunteered when this project was established. More recently there have been changes in the composition of the group. There are five faculty (professors from NC State, Penn State, University of Arkansas, University of Minnesota, and Utah State University), one ARS researcher, one data scientist/programmer (NC State), and one research scholar. Dr. John Spargo from Penn State represents the Northeastern region (NECC-1012), Drs. Deanna Osmond (NC State University) and Nathan Slaton (University of AR) represent the Southern region (SERA-6), Dr. Dan Kaiser (University of MN) represents the North Central region (NCERA-13), while Dr. Matt Yost (Utah State University) represents the Western and Mountain regions (WERA-103). Drs. Kleinman and Osmond represent SERA-17. As representatives from WERA-103 and NCERA-13 are newly added, those organizations will determine who and how representatives are rotated onto and off the executive team, but their tenure must be a minimum of two years. Penn State will continue to represent NECC-1012, which is a very small group, and the SERA-6 representatives will continue as the FRST project started in that region and anyone that wanted to serve could volunteer. The executive committee meets twice a month to ensure the timely completion of current activities. They also discuss new funding and activity opportunities and different management components as they arise.

Budget

The project is currently funded by USDA-NRCS through March 2024, with the spending categories provided below. This will represent four years of funding and we had an additional

three years of prior funding from USDA-ARS that overlapped with NRCS funding, which paid for one each post-doctoral and research scholar salaries. The post-doctoral associate, Dr. Austin Pearce, who left in October 2022, led the activities to determine the relative yield definition and the critical soil test value model. The research scholar, Dr. Sarah Lyons, developed the Excel database as she curated and added legacy data. She also has worked on data configuration for the survey data and provided support for colleagues submitting data to Ag Data Commons for publication. She will continue this activity as collaborators ask. The programmer has developed the relational database and is programming the FRST decision tool. Supplies and materials are primarily for computers and other necessary software costs. Current services have paid for state-level soil test correlation and calibration trials (2021) and laboratory costs associated with the soil depth translation project. Journal publications are also charged to Current Services. Travel has and will pay for travel to scientific meetings for those presenting information on FRST.

USDA-NRCS Description (April 2020-March 2024)	**Current Budget**
EHRA Non-Teaching Salaries	487,404.00
Staff Benefits	149,714.00
Total Personnel Expenditures	**$637,118.00**
Contracted Services	1,000.00
Supplies and Materials	13,091.00
Travel-Domestic	50,882.00
Current Services	204,000.00
Total Direct Costs	**$909,091.00**
Total Indirect Costs	$90,909.00
Total Expenditures	**$1,000,000.00**

Since application to the NRSP is for five years, we will use resources provided by NRCS for the next two years, while we continue to try to find resources from federal agencies, not-for-profit organizations, and corporations. We are also asking for NRSP funding of $212,000 ($70,667 per year) from 2024-2027 as follows:

NRSP Description (2024-2027)	**Current Budget**
SHRA Non-Teaching Salaries	150,000
Staff Benefits	50,000
Total Personnel Expenditures	**200,000**
Current Services	12,000
Total Expenditures	**212,000**

The funding for salaries will pay for a part-time programmer for the FRST decision tool and current services will pay for journal publication (two per year). We recognize that NRSP funding is not on-going and we will continue to look for funding from both the public and private sectors, as we have continued to do throughout the life of the project.

D. Integration: By its very nature, the FRST project is well-integrated. Many collaborators maintain a mixture of extension, research, and/or teaching appointments. The development of the FRST tool is based on research, some of which has been performed during this project, but the execution of the decision tool is an applied outreach tool. Expectations are that faculty will include some of the published work from FRST into class discussion; for instance, inclusion of the Minimum Dataset paper, to provide guidance on best practice in soil correlation and calibration trials, would be an excellent teaching tool for a graduate-level soil fertility course. Demonstrations of the FRST tool would also be an excellent source of material for extension outreach and presentations, and could provide valuable material to an international audience for similar projects to take place worldwide.

E. Outreach, Communications, and Assessment*:* Because FRST is heavily skewed by many extension specialists that are part of the project, extension was baked into the project from the beginning. The elements expected for this project are described below.

1.There are several different intended audiences of FRST as discussed in the objectives. The initial audience is soil fertility faculty at land grant universities where the intent is to develop a community of practice to galvanize interest and participation around soil fertility, particularly as the number of faculty in the field is declining and administrators are reluctant to continue funding this work. This community has formed and stays connected through monthly meetings that engage faculty. Collaborators are and will continue to be asked for feedback on whatever activities are current in addition to providing data for the database when available. Additionally, subsets of volunteer collaborators are more directly involved in activities as they come about. Widespread participation from the soil fertility community in project activities is intended to provide consistent nutrient management decision making. A second intended audience is end users, including producers, CCAs, commercial soil test laboratories, and soil and water district and NRCS employees, who can access and use the FRST decision tool to help them determine the soil test critical value above which additional nutrients will not increase yield.

2.. The executive team (FRST stakeholder advisory committee) is committed to engagement of the multiple stakeholder groups by ensuring that the project stays focused, on-schedule, and representative of all geographical regions in the U.S. Once the decision support tool is ready for beta-testing, another 11-member stakeholder advisory committee will be developed consisting of two farmers, two CCAs, two commercial soil test lab personnel, two collaborators from FRST, two executive team members from FRST, and the programmer to provide continuous feedback on the development of the FRST decision tool. It will be critically important to also provide all collaborators the opportunity to provide feedback on the decision tool; the national soil fertility faculty must support the outcomes of the tool or it will not be promoted and/or used. Once the tool is developed, we will urge collaborators to provide local outreach to their farmers, CCAs, agency personnel including NRCS, private labs, and any other group involved in nutrient decision making. Assuming that many land grant institutions choose to use FRST in P and K fertilizer recommendation rates and promote the tool to user groups, we cannot assure that the outside user groups will use the tool, although there appears to be industry interest. This project

is focused on harmonizing recommendations across land grant universities for soils within similar physiographic regions as a starting point..

3. The most obvious measures of accomplishments are the large national community of practice we have developed, the peer-reviewed journal articles published, the two symposia we were invited to present at Soil Science Society of America International meetings, and programming of the decision tool. These outcomes are and will continue to be available on our website (soiltestfrst.org). We expect to continue publishing and potentially providing more symposia. Once complete, the transference and use of the FRST decision tool will provide both the most important outcome and impact. The impact of journal articles will be followed by documenting the number of citations, downloads, and Altmetric Attention Score, which includes media mentions (e.g., social networks, mainstream news, public policy documents). To date, the FRST Project has published five papers in refereed journals, been featured in CSA News (the official member magazine for the ASA, CSA, and SSSA), and the CSA News developed a short promotional video for social media. Based on Altmetric scores, all articles have received outstanding attention (see summary below).

- Pearce et al. (2022) Defining relative yield for soil test correlation and calibration trials in the fertilizer recommendation support tool. https://doi.org/10.1002/saj2.20450
    - Altmetric Score of 9 (https://wiley.altmetric.com/details/129290529)
    - In the top 25% of all research outputs scored by Altmetric
    - High Attention Score compared to outputs of the same age and source (88th percentile)
    - #6 of 45 outputs of similar age from Soil Science Society of America Journal
- Slaton et al. (2022) Minimum dataset and metadata guidelines for soil-test correlation and calibration research. https://doi.org/10.1002/saj2.20338
    - Altmetric Score of 10 (https://wiley.altmetric.com/details/116200503)
    - In the top 25% of all research outputs scored by Altmetric
    - High Attention Score compared to outputs of the same age and source (90th percentile)
    - 4 of 30 outputs of similar age from Soil Science Society of America Journal
- Lyons et al (2021)) Development of a soil test correlation and calibration database for the USA. https://doi.org/10.1002/ael2.20058
    - Altmetric Score of 4 (https://wiley.altmetric.com/details/119018070)
    - Good Attention Score compared to outputs of the same age and source (65th percentile)
- Zhang et al. (2021) Variation in soil-test-based phosphorus and potassium rate recommendations across the southern USA. https://doi.org/10.1002/saj2.20280
    - Altmetric Score of 16 https://wiley.altmetric.com/details/108142254)
    - In the top 25% of all research outputs scored by Altmetric
    - High Attention Score compared to outputs of the same age and source (88th percentile)
    - #4 of 25 outputs of similar age from Soil Science Society of America Journal

- Lyons et al. (2020) FRST: A national soil testing database to improve fertility recommendations. https://doi.org/10.1002/ael2.20008
    - Altmetric Score of 12 (https://wiley.altmetric.com/details/79000951)
    - In the top 25% of all research outputs scored by Altmetric
    - High Attention Score compared to outputs of the same age and source (81st percentile)
    - #41 of 187 outputs from Agricultural & Environmental Letters
- McCauly (2020) The FRST National Soil Fertility Database. Published in CSA News, June 2020
    - Altmetric Score of 18 (https://acsess.onlinelibrary.wiley.com/doi/10.1002/csan.20218)
    - Article received 28 tweets from 24 users with 82,011 total followers
    - 2-minute promotional video was circulated on social media.

4. Early into FRST we developed a robust website (soiltestfrst.org) that provides a robust repository of outreach and outcomes; it provides communications describing the activities, accomplishments, and impacts of the NRSP. At soiltestfrst.org, access to all our collaborators, many FRST presentations, two-page fact sheets and short videos that have or will continue to be developed for each relevant activity, links to our peer-reviewed publications, and a link to our decision tool when it becomes available are available. The soiltestfrst.org communicates the breadth and scope of this national soil fertility project as a NRSP. The impact of the FRST website will be tracked with Google Analytics. Journal and land grant university communications departments have been and will continue to be used to promote project efforts and accomplishments.

5. Mechanisms for distribution of project results are similar to the communication of project activities, accomplishments and impacts as we are distributing project results through the website (soiltestfrst.org) that archives activities into specific outputs: goals and objectives, funding, project team and collaborators, presentations, resources, and contact. The FRST project has already provided two symposia at two annual Soil Science Society of America meetings (2019 & 2021), as well as presentations at several other professional meetings, including CCA training, regional NIFA soil test meetings, and private sector venues, such as The Fertilizer Institutes annual meeting. Many of these presentations are available through the website as are all our publications. We will continue to seek international, national, and regional symposia opportunities and use social media resources to promote project highlights. Currently, we are planning a series of webinar presentations for CCAs and soil test labs regarding FRST - the algorithms we are standardizing and the tool we are developing.

Every paper, presentation, and the website acknowledges our sponsors. Should we obtain NRSP support from Hatch MRF via SAES and NIFA, we would acknowledge them just as we have our current funders.

6. Data management has been central to the conceptualization and development of FRST. Our data storage, FRST decision tool, and collaborator data papers are within Ag Data Commons, which is part of the National Ag Library. AgCROS (Agricultural Collaborative Research Outcomes System), a USDA-ARS website that "provides information, data, and data resources links to some of the USDA Agricultural Research Service (ARS) Natural Resources, Genomics, and Nutrition efforts', is under the umbrella of Ag Data Commons. AgCROS is designed with the intent to provide agricultural research data to the public research and development community (https://agcros-usdaars.opendata.arcgis.com). Once the FRST legacy database is fully developed, it will be accessible to agricultural researchers.

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NRSP Review (Submitted)

Project: Building Collaborative Research Networks to Advance the Science of Soil Fertility: Fer

Dates Covered 10/01/2023 - 09/30/2028

The following statement defines the mission of the National Research Support Projects (NRSP's):

NRSP Mission: National Research Support Projects (NRSPs) focus on the development of enabling and critical technologies (e.g., databases, cyberinfrastructure, on-line toolkits, reagents), support activities (e.g., collect, assemble, store, and distribute materials, data, resources or information) or the sharing of facilities (e.g., analytical equipment, lab, field) needed to accomplish high priority research.

Based on this mission, please rate the proposed NRSP using the following criteria.

	Satisfactory	Unsatisfactory
Mission:		
Consistency with the NRSP mission	◉	○
Relevance:		
Addresses and supports a high priority national issue	◉	○
Demonstrates clear and tangible benefits to the scientific community as a whole	◉	○
Clearly identified sponsoring beneficiary stakeholders	◉	○
Stakeholder involvement in project development, project activities, review, and/or management plans	◉	○
Technical Merit:		
Overall technical merit (sound scientific approach, achievable objectives, review, and/or management plans	◉	○
Potential for significant outputs (products) and outcomes with impacts	◉	○
Implementation Plan:		
Benchmarks for success clearly identified	◉	○
Management structure that adequately coordinates efforts of multiple participants	◉	○
Well-developed business plan that captures multiple sources of funding and leverages OTT MRF	◉	○
Funding plan that develops alternative funding sources to reduce OTT MRF in future years	◉	○
Efforts integrated with Extension, academic, or international programs	◉	○
Outreach, communications and assessment plan that communicates the program goals, accomplishments, and outcomes, and impacts	◉	○

Comments (Please add general and specific comments on strengths and weaknesses of the proposal, including specific revisions that would improve the proposal):

The group has an established record of reaching consensus and adoption of a small(er) group of soil test methods for P and K. It is a logical next step to address the recommendation end of t robust team is well positioned to make progress in this area. The team is established and has already delivered many useful scholarly, database, and decision products that lay a solid foundat of implementation.

I really like the national database approach. Much learning can occur by various researchers and locales sharing data beyond the final recommendation table. This should lead to additional le inform future research intended to improve fertilizer recommendations but also other end-use management. This approach also addresses an ongoing problem is turnover and loss of scientific states/regions. By collaborating across states and regions, gaps in human capacity and knowledge can be filled.

Minor point - In the budget, I was not clear what the acronym EHRA stood for. Likely not important to my understanding.

Recommendations
One challenge we have faced in developing a database for shared data input is data quality and curation. I assume the team has worked this out but if not would advise they give careful thouc quality and manage errant data. Related, how will the database accept older datasets that might be of high value but not conform to present-day data requirements. Perhaps identifying tier 1, differentiate on the basis of completeness and/or quality?

Overall Recommendation: Approve

Cancel (https://www.nimss.org/review/my_reviews)

Report a Bug

NRSP Review (Submitted)

Project: Building Collaborative Research Networks to Advance the Science of Soil Fertility: Fer

Dates Covered 10/01/2023 - 09/30/2028

The following statement defines the mission of the National Research Support Projects (NRSP's):

NRSP Mission: National Research Support Projects (NRSPs) focus on the development of enabling and critical technologies (e.g., databases, cyberinfrastructure, on-line toolkits, reagents), support activities (e.g., collect, assemble, store, and distribute materials, data, resources or information) or the sharing of facilities (e.g., analytical equipment, lab, field) needed to accomplish high priority research.

Based on this mission, please rate the proposed NRSP using the following criteria.

	Satisfactory	Unsatisfactory
Mission:		
Consistency with the NRSP mission	◉	○
Relevance:		
Addresses and supports a high priority national issue	◉	○
Demonstrates clear and tangible benefits to the scientific community as a whole	◉	○
Clearly identified sponsoring beneficiary stakeholders	◉	○
Stakeholder involvement in project development, project activities, review, and/or management plans	◉	○
Technical Merit:		
Overall technical merit (sound scientific approach, achievable objectives, review, and/or management plans	◉	○
Potential for significant outputs (products) and outcomes with impacts	◉	○
Implementation Plan:		
Benchmarks for success clearly identified	◉	○
Management structure that adequately coordinates efforts of multiple participants	◉	○
Well-developed business plan that captures multiple sources of funding and leverages OTT MRF	◉	○
Funding plan that develops alternative funding sources to reduce OTT MRF in future years	◉	○
Efforts integrated with Extension, academic, or international programs	◉	○
Outreach, communications and assessment plan that communicates the program goals, accomplishments, and outcomes, and impacts	◉	○

Comments (Please add general and specific comments on strengths and weaknesses of the proposal, including specific revisions that would improve the proposal):

Strengths:
* This project represents a unique and major coordinated effort to provide more uniform soil test procedures and interpretations with the goal of improving fertilizer use on a national scale.

* The effort has involved over 40 highly qualified soil fertility specialists/scientists/agronomists throughout the US

* There is strong evidence of cooperation based on multiple authored papers in high quality peer reviewed journals

* The participants should be commended for a well written proposal and organizing a highly relevant multistate national project that has important implications for improving the value of soil tes making fertilizer recommendations.

Weaknesses and suggestions for improvement:

* Given that a number of public (university) soil testing labs have closed in recent years, many growers and consultants now rely on private labs for fertilizer recommendations. Therefore, it w important to engage more fully with some key private labs as this project moves forward. While private labs are listed as stakeholders it is unclear how they might be involved. Getting input fr private labs during the process (as opposed to after changes are made based on the research) will be important for adoption.

* While improved correlation and calibration data are important on a national scale, the data collected will be crop specific. There is no mention in the proposal which crops will be targeted. I that corn will be a major crop being tested, but it would be helpful if a few major crops were listed.

Overall Recommendation: Approve

Report a Bug

NRSP Review (Submitted)

Project: Building Collaborative Research Networks to Advance the Science of Soil Fertility: Fe

Dates Covered 10/01/2023 - 09/30/2028

The following statement defines the mission of the National Research Support Projects (NRSP's):

NRSP Mission: National Research Support Projects (NRSPs) focus on the development of enabling and critical technologies (e.g., databases, cyberinfrastructure, on-line toolkits, reagents), support activities (e.g., collect, assemble, store, and distribute materials, data, resources or information) or the sharing of facilities (e.g., analytical equipment, lab, field) needed to accomplish high priority research.

Based on this mission, please rate the proposed NRSP using the following criteria.

	Satisfactory	Unsatisfactory
Mission:		
Consistency with the NRSP mission	◉	○
Relevance:		
Addresses and supports a high priority national issue	◉	○
Demonstrates clear and tangible benefits to the scientific community as a whole	◉	○
Clearly identified sponsoring beneficiary stakeholders	◉	○
Stakeholder involvement in project development, project activities, review, and/or management plans	◉	○
Technical Merit:		
Overall technical merit (sound scientific approach, achievable objectives, review, and/or management plans	◉	○
Potential for significant outputs (products) and outcomes with impacts	◉	○
Implementation Plan:		
Benchmarks for success clearly identified	◉	○
Management structure that adequately coordinates efforts of multiple participants	◉	○
Well-developed business plan that captures multiple sources of funding and leverages OTT MRF	◉	○
Funding plan that develops alternative funding sources to reduce OTT MRF in future years	◉	○
Efforts integrated with Extension, academic, or international programs	◉	○
Outreach, communications and assessment plan that communicates the program goals, accomplishments, and outcomes, and impacts	◉	○

Comments (Please add general and specific comments on strengths and weaknesses of the proposal, including specific revisions that would improve the proposal):

This is truly integrated effort that will benefit almost all of cropland agriculture in the US.

Overall Recommendation: Approve

Cancel (https://www.nimss.org/review/my_reviews)

Report a Bug

NRSP Review (Submitted)

Project: Building Collaborative Research Networks to Advance the Science of Soil Fertility: Fer

Dates Covered 10/01/2023 - 09/30/2028

The following statement defines the mission of the National Research Support Projects (NRSP's):

NRSP Mission: National Research Support Projects (NRSPs) focus on the development of enabling and critical technologies (e.g., databases, cyberinfrastructure, on-line toolkits, reagents), support activities (e.g., collect, assemble, store, and distribute materials, data, resources or information) or the sharing of facilities (e.g., analytical equipment, lab, field) needed to accomplish high priority research.

Based on this mission, please rate the proposed NRSP using the following criteria.

	Satisfactory	Unsatisfactory
Mission:		
Consistency with the NRSP mission	◉	○
Relevance:		
Addresses and supports a high priority national issue	◉	○
Demonstrates clear and tangible benefits to the scientific community as a whole	◉	○
Clearly identified sponsoring beneficiary stakeholders	◉	○
Stakeholder involvement in project development, project activities, review, and/or management plans	◉	○
Technical Merit:		
Overall technical merit (sound scientific approach, achievable objectives, review, and/or management plans	◉	○
Potential for significant outputs (products) and outcomes with impacts	◉	○
Implementation Plan:		
Benchmarks for success clearly identified	◉	○
Management structure that adequately coordinates efforts of multiple participants	◉	○
Well-developed business plan that captures multiple sources of funding and leverages OTT MRF	◉	○
Funding plan that develops alternative funding sources to reduce OTT MRF in future years	◉	○
Efforts integrated with Extension, academic, or international programs	◉	○
Outreach, communications and assessment plan that communicates the program goals, accomplishments, and outcomes, and impacts	◉	○

Comments (Please add general and specific comments on strengths and weaknesses of the proposal, including specific revisions that would improve the proposal):

The proposal is well-written and the concept presented is clear. The work addresses a national need that has not received due attention in the past few decades mostly because funding for th research has been sparse. The scientific capacity across the land grant university system is in place to accomplish the objectives. Kudos to the project leaders for organizing a national team a it to set lofty goals that will save producers money and protect the environment if accomplished. The team consists of diverse, well-seasoned, and experienced soil fertility experts who are cap accomplishing the goals while also training the next generation of university faculty and industry representatives. The involvement of NECC-1012, SERA-6, SERA-17, NCERA-13, and WERA- excellent and will keep the momentum going with time. Project objectives are specific, measurable, achievable, and realistic. The time-bound component is not stated, but we can assume the achieve the objectives is the 5-year life of the proposal. Addressing phosphorus and potassium is a large enough task on its own. Both P and K directly relate to soil test calibration and fertilize some point it would be valuable to evaluate the variation in nitrogen fertilizer rate recommendations across regions, although soil testing would not be involved with N in most cases (dependin The project budget is relatively modest relative to the amount of work required but this team should be able to accomplish a lot with the funding available as they seek additional funding from c Considering who the project leaders are, the fact that an extension component is "baked in" is not surprising. This work will be of high value to stakeholders outside the academic community, p private labs, CCAs, and producers. The land grant universities are poised to teach these groups as new information is generated. The proposal describes the research papers that will emerge project, but it would be handy to also describe the types of extension publications that will be produced.

Overall Recommendation: Approve

Cancel (https://www.nimss.org/review/my_reviews)

Report a Bug

NRSP Review (Submitted)

Project: Building Collaborative Research Networks to Advance the Science of Soil Fertility: Fe

Dates Covered 10/01/2023 - 09/30/2028

The following statement defines the mission of the National Research Support Projects (NRSP's):

NRSP Mission: National Research Support Projects (NRSPs) focus on the development of enabling and critical technologies (e.g., databases, cyberinfrastructure, on-line toolkits, reagents), support activities (e.g., collect, assemble, store, and distribute materials, data, resources or information) or the sharing of facilities (e.g., analytical equipment, lab, field) needed to accomplish high priority research.

Based on this mission, please rate the proposed NRSP using the following criteria.

	Satisfactory	Unsatisfactory
Mission:		
Consistency with the NRSP mission	◉	○
Relevance:		
Addresses and supports a high priority national issue	◉	○
Demonstrates clear and tangible benefits to the scientific community as a whole	◉	○
Clearly identified sponsoring beneficiary stakeholders	◉	○
Stakeholder involvement in project development, project activities, review, and/or management plans	◉	○
Technical Merit:		
Overall technical merit (sound scientific approach, achievable objectives, review, and/or management plans	◉	○
Potential for significant outputs (products) and outcomes with impacts	◉	○
Implementation Plan:		
Benchmarks for success clearly identified	◉	○
Management structure that adequately coordinates efforts of multiple participants	◉	○
Well-developed business plan that captures multiple sources of funding and leverages OTT MRF	◉	○
Funding plan that develops alternative funding sources to reduce OTT MRF in future years	◉	○
Efforts integrated with Extension, academic, or international programs	◉	○
Outreach, communications and assessment plan that communicates the program goals, accomplishments, and outcomes, and impacts	◉	○

Comments (Please add general and specific comments on strengths and weaknesses of the proposal, including specific revisions that would improve the proposal):

Strong project that fills a need for nutrient management guidelines for industry and the land grant university system. The project has excellent participation and is off to a good start with succe activity in seeking funding opportunities. The national project designation will serve as official recognition of the effort's merits and be an encouraging factor for other faculty to participate. The strong mentoring system for faculty across experience levels.

Overall Recommendation: Approve

Cancel (https://www.nimss.org/review/my_reviews)

Report a Bug

Technical Response (Submitted)

Technical Response Review

Project Number: Building Collaborative Research Networks to Advance the Science of Soil Fertility: Fertilizer Recommendation Support Tool (FRST)

Comments:

Weaknesses and suggestions for improvement:
1. Given that a number of public (university) soil testing labs have closed in recent years, many growers and consultants now rely on private labs for fertilizer recommendations. Therefore, it will be important to engage more fully with some key private labs as this project moves forward. While private labs are listed as stakeholders it is unclear how they might be involved. Getting input from private labs during the process (as opposed to after changes are made based on the research) will be important for adoption.

We very much agree with the above comments and as such, we have been engaging with ALTA (The Agricultural Laboratory Testing Association), an organization of professionals dedicated to: quality soil testing, accurate reporting, sound management advice, and information sharing. Many in this group manage private-sector soil test labs and the leadership of ALTA is very interested in working with the FRST team. We will be attending their annual meeting in March and providing presentations on our work that affects them. We are discussing a possible survey of private labs through ALTA. Discussions with ALTA have already been instrumental to our work as we have learned that many soil test labs no longer make recommendations; they simply provide analytical results to the advisors who then make the fertilizer recommendations. Working with ALTA on the FRST project and decision tool will be iterative and critical to the integration of the private sector. We will also pursue other private-sector opportunities.

2. While improved correlation and calibration data are important on a national scale, the data collected will be crop specific. There is no mention in the proposal of which crops will be targeted. It is likely that corn will be a major crop being tested, but it would be helpful if a few major crops were listed.

We have focused on corn, soybeans, small grains, cotton, and hay but we also have data from other crops (see below). The FRST database is open to data from all crops. The benefits of the national database are arguably more important for crops grown on limited or minor acreage and typically have fewer land grant resources (e.g., FTEs and commodity-based funding sources) for soil-test correlation and calibration research than large-acreage crops like corn and soybean. Regardless of the crop, the power of having a national approach and data sharing is having data from multiple sources in the same database to strengthen the number of observations available for soil-test correlation calibration. The list below will help identify crops that lack sufficient soil-test correlation and calibration data and require additional research and resources.
The crop, number of K trials, number of P trials, and total number of publications are listed: Alfalfa 11 16 6; Bahiagrass 0 1 1; Barley 0 12 1; Bermudagrass 32 32 1; Brachiariagrass 0 1 1; Camelina 0 5 1; Chickpea 0 3 1; Clover-grass mix 0 2 1; Coastal bermudagrass 3 0 2; Corn grain 320 358 30; Corn silage 0 17 1; Cotton 45 23 9; Flax 0 8 1; Grain sorghum 1 20 4; Lentil 0 8 2; Oats 0 1 1; Pea 0 12 4; Peanut 3 2 2; Potato 0 2 1; Rice 56 24 2; SorghumxSudangrass 1 0 1; Soybean 270 229 23; Spring wheat 0 3 1; Sugarcane 6 4 2; Sweet potato 5 3 1; Winter wheat 10 41 7.

3. One challenge we have faced in developing a database for shared data input is data quality and curation. I assume the team has worked this out but if not would advise they give careful thought to how to ensure quality and manage errant data. Related, how will the database accept older datasets that might be of high value but not conform to present-day data requirements. Perhaps identifying tier 1, tier 2, etc. datasets to differentiate on the basis of completeness and/or quality?

We absolutely agree that data quality and curation is critical. Since the beginning of FRST we have worked with Dr. Sylvie Brouder and the National Agricultural Library to ensure that our database ontology was appropriate. The majority of legacy data entered into the FRST has been obtained from refereed journals and other publications; we have to assume that the researchers have inspected their data prior to publishing for errors. The FRST team has taken every effort to ensure the data has been correctly copied and imported into the FRST database. For raw datasets that have been submitted, we also need to assume (and try to ensure by asking) researchers to only submit clean and correct data to the database. The legacy data is typically less complete than current data we are entering that ascribes to the minimum dataset categories that the FRST project delineated (https://doi.org/10.1002/saj2.20338). For data collected from ongoing and future trials, the minimum dataset guidelines for “required data” include measures of variance for the required soil test P and K values and yield data. The minimum dataset establishes a protocol for scientists to share and publish raw data which will enable database users (e.g., researchers) to vet data quality with statistical analyses. We will continue to promote the minimum dataset as a set of guidelines for soil-test correlation and calibration research as one strategy of promoting and assessing data quality. We will register the FRST database with Ag Data Commons (National Ag Library), which will provide a citation under FRST authorship.

The FRST software engineer is performing checks in the program to ensure all datasets that are entered contain the minimum data required for inclusion, the data is entered in the correct format, and the metadata (county names, state postal codes, soil series, soil map units, soil textures, soil taxonomic names, etc.) are correct. He is using the SSURGO database to confirm the soil related information. For location checking, he has location information (state, county and FIPS codes) stored in the database which he pulled from U.S. Census Agency. Most of the checks are to ensure the data can be properly filtered/grouped and analyzed within the program.

We have discussed rating datasets, like BFDC did with their data ("A" and "B" quality, for example). However, we are not sure how that information will be applied to the tool results other than reporting how many datasets are the top tier versus lower tiers. At this point, we need as much data as we can obtain. As far as rating datasets, we do not see that currently there is much to be gained. If in the future, though, we wanted to automatically generate database categories, the categories would probably be:
Tier 1 – Datasets that contain all original summary and rep data
Tier 2 – Datasets that contain all original summary data
Tier 3 – Datasets that contain data that has been estimated (interpreted from graphs)

Finally, as stakeholders use the tool and filter datasets, they will have the ability to control which datasets they include. If an individual decides a dataset appears to contain data inconsistent with the related datasets, they will have the option to exclude it. At this point, it is their responsibility to justify the exclusion and we can offer them an option to report it to FRST so the dataset can be checked.

Building Collaborative Research Networks to Advance the Science of Soil Fertility:

Fertilizer Recommendation Support Tool (FRST)

A. *Statement of Issues and Justification:* Soil testing and the recommendations derived from laboratory analyses provide the backbone for nutrient management in modern agricultural production systems. However, most science-based soil fertility recommendation systems for phosphorus (P) and potassium (K) fertilizer guidance are based on decades-old soil-test relationships that were developed within states in the 1950s-1970s (Spargo et al., 2022). While soil testing has the common goal of determining which nutrients are needed and how much fertilizer to apply, soil-testing laboratories in the U.S. use different analytical methods, interpretations, and philosophical approaches when making fertilizer or nutrient recommendations. The NIFA soil test regional work groups (NCERA-13, NECC-1012, SERA-6, and WERA-103) have provided good guidance for analytical methods and today, five soil test extractants are used to analyze P and/or K of most soil samples in the USA (Spargo et al., 2022). Additionally, all university labs participate in either the North American Proficiency Testing (NAPT) Program or the Agricultural Lab Proficiency (ALP) Program to assure the accuracy and precision of soil test results. Thus, the differences in soil-test-based nutrient recommendations among labs across states with similar physiographic areas and soils are most often due to older calibration and correlation study results and interpretations of the results (e.g. philosophical choices).

Conflicting and outdated recommendations across state boundaries lead to end-user confusion and reduced confidence in soil testing, which ultimately proves detrimental to research and educational efforts that encourage 4R Nutrient Stewardship. The 4R Nutrient Stewardship program is the backbone of USDA-NRCS Nutrient Management Standard designed to optimize nutrient use while minimizing off-site impact of nutrients on water quality. Despite long-standing regional efforts to maintain communication and coordination across soil testing programs, Zhang et al. (2020) demonstrated that land grant recommendations from university or state labs within the Southern region using the same soil test extractants had P recommendations that varied by a factor of 2.5. These differences across state lines were primarily based on best professional judgment rather than empirical evidence. Scientifically defensible soil-test recommendations are fundamental to agricultural production and environmental protection.

To advance the precision of soil test recommendations and, where appropriate, dissociate them from state boundaries, we developed the Modernizing Fertilizer Recommendations: Fertilizer Recommendation Support Tool, or “FRST”, project, which we believe is foundational to farmers and nutrient management conservation efforts nationwide. By optimizing nutrient use and decreasing nutrients at the source, and thereby increasing the effectiveness of conservation practices, both farmers and taxpayers will save millions of dollars annually and protect the environment by reducing off-site nutrient loss. While the responsibility of interpreting soil test results and developing recommendations will remain with land-grant soil fertility faculty of each state, FRST aims to stimulate cooperation among states and across regions, providing valuable data and resources for up-to-date and science-based fertilizer recommendation systems, including standardizing the equations for the relative yield value and critical soil test value, in order to reduce differences in recommendation philosophies.

State-based, soil-test correlation databases seldom have enough site-years and diversity to develop recommendations based on factors other than soil-test P or K. Development of the national soil-test correlation database for legacy, current, and future research results will be instrumental in developing recommendations that consider covariates that can make nutrient recommendations specific for production systems with different crop yield potentials, soil properties that influence nutrient availability (e.g., soil pH and clay content), and factors like drainage and slope that influence nutrient movement. It is possible that analysis of the large, diverse database may show that soil test critical nutrient values and the resulting fertilizer-nutrient rate recommendations should be different among geographic regions.

Standardization of soil-test-based nutrient use recommendations is one possible outcome when data from multiple states are analyzed together, but standardization of recommendations is not the end goal of this project. The most important outcomes of the FRST Project are making soil-test-based fertilizer recommendations more scientifically defensible and more accurate, increasing end-user confidence in fertilizer recommendations, and developing a consistent soil-testing vocabulary and with clear definitions of the term used in the soil-testing industry. All of these goals require extensive research to analyze data and open conversations with all stakeholders and industry segments to develop a consensus and seek out all educational opportunities to disseminate the information.

The FRST project is composed of over 100 individuals representing 41 land-grant (40 states and one territory), two state universities, one private university, three USDA divisions (Agricultural Research Service, Natural Resources Conservation Service and Farm Service Agency), three not-for-profit organizations, and one State Department of Agriculture. The collaborative nature of the FRST project is at its core. Many of the FRST collaborators are members of one of the four existing multi-state soil testing projects: NCERA-13, NECC-1012, SERA-6, and WERA-103. Additionally, SERA-17 has been engaged in the FRST effort. The need for a national project like FRST was discussed at a joint meeting of the Regional Soil Testing Multi-state groups held at Penn State (July 2016).

There are eight FRST activities leading to the development of the FRST decision tool that will initially provide critical soil test values based on selected parameters such as region, soil classification, crop, and other metadata. Longer-term, the FRST tool will provide recommendations, again based on user criteria selection.

Activities include:

1) Surveyed soil fertility faculty at land grant universities on current soil fertility practices and recommendations to better understand the current status of soil testing across the U.S. and identify opportunities to harmonize nutrient management guidelines (Spargo et al., 2022);

2) A team of land grant soil fertility faculty developed a minimum dataset for future soil test correlation and calibration trials to guide research in the U.S. (Slaton et al., 2021);

3) Developed the FRST database to preserve legacy data and add new soil test correlation and calibration P and K data (Lyons et al., 2021);

4) Explored and determined the most appropriate relative yield calculation for use in the FRST decision support tool (Pearce et al., 2022);

5) Supported state-level soil test correlation and calibration trials during 2021 funded by FRST;

6) Developing a multi-state analysis of soil sampling depth influence on soil test outcomes in order to translate between different soil depths;

7) Determined the soil test correlation model most appropriate for the FRST decision tool (Pearson et al., 2022 in review), and;

8) Developing a user-friendly decision support tool to provide soil test user information for a soil-test and crop-response-to-fertilization searchable web-based decision tool. This tool will provide more consistent, transparent, and science-based decisions for nutrient recommendations.

Activities 2, 4 and 5 have been completed, while activity 1 and 7 are almost complete. We have started activities 6. Activity 3 and 8 will be ongoing during the life of the project and require long-term support for the success of this initiative.

Project activities are not fixed. Some activities were started at the beginning of the project while others began through collaborator group discussions around specific topics, such as the appropriate definition for relative yield. Other activities have been added as individual interest has aligned with need, like a sub-committee looking into updating lime recommendations. A new activity suggested by faculty collaborators is to compare P and K nutrient recommendations within the Western and Mountain regions similar to what a southern regional group did (Zhang et al., 2020). Another suggestion was to possibly add sulfur to the database. We expect new activities to be suggested from collaborators, accepted or declined based on need and funding, and if accepted, brought to fruition. The large collaborator group allows for new activities to be nominated and added as resources allow.

We have two primary stakeholder groups: the soil fertility research community and agricultural practitioners, such as producers, certified crop advisors (CCAs), fertilizer dealers, etc. The soil fertility community, both researchers at land grant universities and USDA-ARS, as well as practitioners in the federal government, primarily NRCS, are our soil fertility research community stakeholders. The farming community will be both primary and secondary stakeholders, as they will not only have direct access to the FRST tool, but will also benefit from improved fertilizer recommendations developed by the research community supported by FRST. USDA-NRCS 590 Nutrient Management Standard is foundational to conservation practices and FRST should support a more robust 590 standard to optimize nutrients for the producer while minimizing the off-site environmental impact.

As mentioned, the soil fertility research community is actively involved in monthly meetings, current activities, and proposing new activities. By forming a community of practice, we are increasing the knowledge of the collaborators and working on research topics of interest to many. When the database is sufficiently robust, we will allow the research community to access the data for further exploration of soil test correlation and calibration trials. Access to the database will support work by many types of researchers and extension scientists, beyond soil fertility, such as crop physiologists, agro climatologists and modelers. The minimum dataset will

ensure that the database is populated with all relevant data that could be used to further the investigation of topics around soil fertility, including soil texture, soil sampling depth, and other environmental parameters (Slaton et al., 2021).

Once there is a beta version of the FRST decision tool, our stakeholder community expands to include additional users – farmers, CCAs, private soil test laboratory professionals, and others. We have begun to interact with the private soil test laboratory professionals, who are eager to participate and believe this will help the credibility of recommendations. We will solicit participation from these groups to provide feedback and suggestions regarding the functioning of the tool and the usefulness of the output. This will be a highly interactive process.

***B. Objectives and Projected Outcomes**:*

Goals

The **primary goal** of FRST is to address the national issue of soil testing transparency and accuracy by promoting clear and consistent interpretations of fertilizer recommendations by removing political and institutional (public and private) bias from soil test interpretation and providing the best possible science to enhance end-user adoption of nutrient management recommendations. A **secondary goal** is to provide a catalyst for innovation in soil fertility – useful to those making recommendations as well as those evaluating those recommendations.

Objectives

The primary objectives of the FRST project that the National Research Support Program (NRSP) funding will support are as follows:

1. Develop a community of practice to galvanize interest and participation around soil fertility.
2. Develop a searchable tool that provides soil test correlation and calibration graphs with statistical confidence intervals for the geographic area(s) of interest (general users). The first step will be to identify the critical soil test level above which there is no response (correlation) and the next step will be to provide fertilizer-nutrient rate recommendations when a yield response from fertilization is expected (calibration).
3. Provide data to nutrient management scientists and modelers for in-depth analysis of soil test correlation and calibration data (researchers).

The FRST project has been in existence for four years and follows an activity-based program. The activities have varied end points, which will be listed here. Some of them have been completed while others will be ongoing for the life of the national project.

1) Soil fertility faculty at land grant universities were surveyed on current soil fertility practices and recommendations to better understand the status of soil testing across the U.S. and identify opportunities to harmonize nutrient management guidelines. The survey and all data have been published in Ag Data Commons (National Ag Library; Spargo et al., 2022). A synthesis paper has been written and submitted for publication. There are many other papers that can be developed from the national survey data by whichever collaborators want to work on them. Finally, the data are being shared with stakeholders, such as NRCS, to help them understand how

underfunded soil test correlation and calibration has been in the U.S during the past 40 to 50 years.

2) Developed, with a team of land grant soil fertility faculty, a minimum dataset for future correlation and calibration trials to guide research in the U.S. After two years of frequent meetings, the minimum data set for soil test correlation and calibration trials was published (Slaton et al., 2021) and an Excel spreadsheet template developed that allows researchers to easily capture the necessary data that meets the minimum data requirements. Data for FRST will be spooled from the minimum dataset to the Excel file into the relational database.

3) Development of the FRST database to preserve legacy data and add new soil test correlation and calibration P and K data. The database was developed in Excel then transformed to a relational database structure that includes the legacy data as well as the minimum data set components. Currently the database contains over 1400 K or P trials that represent 26 crops. The database will be tied to and accessible by the FRST decision tool (Lyons et al., 2021). Data will continue to be collected and added to the database over the life of the project. We anticipate that the database will be used extensively by researchers to model and publish soil test correlation results.

4) Explored and determined the most appropriate relative yield calculation for use in the FRST decision support tool by a group of FRST collaborators who volunteered. This was a new activity proposed by the collaborators. After a year of work by the committee, there was consensus around the equation selected for the relative yield calculation, which will be used in the FRST tool. In addition, a journal article was written as there was no literature comparing different relative yield definitions with each other (Pearce et al., 2022).

5) Supported state-level soil test correlation and calibration trials during 2021 funded by FRST. The data derived from these soil test correlation and calibration trials (18) were delivered and entered into the FRST database. A number of these trials also received Ag Data Commons citations (https://soiltestfrst.org/resources/). We will continue to encourage trials as we have resources available.

6) Developing a multi-state analysis of soil sampling depth influence on soil test outcomes to translate between different soil depths. Different states and cropping systems utilize different soil sampling depths. As there was no peer-reviewed publication providing translation soil test values between depths regionally, we began this work during 2021. Scientists from over two-thirds of land grant universities in the U.S. have participated in this study with a total of 2936 samples from 197 unique sites. The protocol was very rigorous and was vetted and approved by all collaborators. Multiple depths were collected, and the soil was analyzed for Mehlich-3 extractable nutrients, pH, organic matter and depending on the geographical location from which it was collected, also Olsen P (western states with pH $\geq$ 7.2) or Modified Morgan P (northeastern states). Collaborators also provided metadata to be able to associate cropping systems and soil characteristics, including texture, with the depth translation. The data are currently being analyzed. The output from this activity will provide translation equations for soils under various cropping systems at different sampling depths in the FRST decision tool. Therefore, we expect multiple translation equations relative to the system and depth sampled.

7) Selecting the soil test correlation model appropriate for determining the critical soil test value is essential for the FRST decision tool. As there are several available models, it is important to consider their strengths and weaknesses, analyze them statistically, and then determine the appropriate model for use in the FRST decision tool. FRST collaborators volunteered to work on this very important committee and after approximately one year of work, the committee selected

8) Development of a user-friendly decision support tool to provide soil test user information for a soil-test and crop-response-to-fertilization searchable web-based decision tool. The output from the tool is the ultimate goal of the project. Users, which include the private sector (e.g. soil test labs, CCAs, etc), will be enlisted to help beta-test the FRST decision tool. Discussions are already underway with a large association of private soil test labs.

Every activity proposed in the FRST project has been assessed based on the outcomes we established. For instance, the minimum dataset was considered successful when the journal article was published, the data entry template for the FRST tool was developed and placed at soiltestfrst.org, and the minimum dataset was used for state-level soil test correlation and calibration trials. Completion of identified details within the activities is important to the collaborators and the success of this project. The executive team meets bi-weekly to assess each activity and ensure that timelines and deliverables are being met. The outcome of all objectives and activities are assessed by participant involvement and the publication and citation of fact sheets and peer-reviewed journal papers. (See section C for more details on the executive team.)

C. Management, Budget, and Business Plan*:* The FRST project has a nine-person executive team composed initially of a self-forming group that volunteered when this project was established. More recently there have been changes in the composition of the group. There are five faculty (professors from NC State, Penn State, University of Arkansas, University of Minnesota, and Utah State University), one ARS researcher, one data scientist/programmer (NC State), and one research scholar. Dr. John Spargo from Penn State represents the Northeastern region (NECC-1012), Drs. Deanna Osmond (NC State University) and Nathan Slaton (University of AR) represent the Southern region (SERA-6), Dr. Dan Kaiser (University of MN) represents the North Central region (NCERA-13), while Dr. Matt Yost (Utah State University) represents the Western and Mountain regions (WERA-103). Drs. Kleinman and Osmond represent SERA-17. As representatives from WERA-103 and NCERA-13 are newly added, those organizations will determine who and how representatives are rotated onto and off the executive team, but their tenure must be a minimum of two years. Penn State will continue to represent NECC-1012, which is a very small group, and the SERA-6 representatives will continue as the FRST project started in that region and anyone that wanted to serve could volunteer. The executive committee meets twice a month to ensure the timely completion of current activities. They also discuss new funding and activity opportunities and different management components as they arise.

Budget

The project is currently funded by USDA-NRCS through March 2024, with the spending categories provided below. This will represent four years of funding and we had an additional

three years of prior funding from USDA-ARS that overlapped with NRCS funding, which paid for one each post-doctoral and research scholar salaries. The post-doctoral associate, Dr. Austin Pearce, who left in October 2022, led the activities to determine the relative yield definition and the critical soil test value model. The research scholar, Dr. Sarah Lyons, developed the Excel database as she curated and added legacy data. She also has worked on data configuration for the survey data and provided support for colleagues submitting data to Ag Data Commons for publication. She will continue this activity as collaborators ask. The programmer has developed the relational database and is programming the FRST decision tool. Supplies and materials are primarily for computers and other necessary software costs. Current services have paid for state-level soil test correlation and calibration trials (2021) and laboratory costs associated with the soil depth translation project. Journal publications are also charged to Current Services. Travel has and will pay for travel to scientific meetings for those presenting information on FRST.

USDA-NRCS Description (April 2020-March 2024)	**Current Budget**
EHRA Non-Teaching Salaries	487,404.00
Staff Benefits	149,714.00
Total Personnel Expenditures	**$637,118.00**
Contracted Services	1,000.00
Supplies and Materials	13,091.00
Travel-Domestic	50,882.00
Current Services	204,000.00
Total Direct Costs	**$909,091.00**
Total Indirect Costs	$90,909.00
Total Expenditures	**$1,000,000.00**

Since application to the NRSP is for five years, we will use resources provided by NRCS for the next two years, while we continue to try to find resources from federal agencies, not-for-profit organizations, and corporations. We are also asking for NRSP funding of $212,000 ($70,667 per year) from 2024-2027 as follows:

NRSP Description (2024-2027)	**Current Budget**
SHRA Non-Teaching Salaries	150,000
Staff Benefits	50,000
Total Personnel Expenditures	**200,000**
Current Services	12,000
Total Expenditures	**212,000**

The funding for salaries will pay for a part-time programmer for the FRST decision tool and current services will pay for journal publication (two per year). We recognize that NRSP funding is not on-going and we will continue to look for funding from both the public and private sectors, as we have continued to do throughout the life of the project.

D. Integration: By its very nature, the FRST project is well-integrated. Many collaborators maintain a mixture of extension, research, and/or teaching appointments. The development of the FRST tool is based on research, some of which has been performed during this project, but the execution of the decision tool is an applied outreach tool. Expectations are that faculty will include some of the published work from FRST into class discussion; for instance, inclusion of the Minimum Dataset paper, to provide guidance on best practice in soil correlation and calibration trials, would be an excellent teaching tool for a graduate-level soil fertility course. Demonstrations of the FRST tool would also be an excellent source of material for extension outreach and presentations and could provide valuable material to an international audience for similar projects to take place worldwide.

E. Outreach, Communications, and Assessment*:* Because FRST is heavily skewed by many extension specialists that are part of the project, extension was baked into the project from the beginning. The elements expected for this project are described below.

1.There are several different intended audiences of FRST as discussed in the objectives. The initial audience is soil fertility faculty at land grant universities where the intent is to develop a community of practice to galvanize interest and participation around soil fertility, particularly as the number of faculty in the field is declining and administrators are reluctant to continue funding this work. This community has formed and stays connected through monthly meetings that engage faculty. Collaborators are and will continue to be asked for feedback on whatever activities are current in addition to providing data for the database when available. Additionally, subsets of volunteer collaborators are more directly involved in activities as they come about. Widespread participation from the soil fertility community in project activities is intended to provide consistent nutrient management decision making. A second intended audience is end users, including producers, CCAs, commercial soil test laboratories, and soil and water district and NRCS employees, who can access and use the FRST decision tool to help them determine the soil test critical value above which additional nutrients will not increase yield.

2.. The executive team (FRST stakeholder advisory committee) is committed to engagement of the multiple stakeholder groups by ensuring that the project stays focused, on-schedule, and representative of all geographical regions in the U.S.

Engaging the private sector will be critical for the success of FRST so we have been meeting with ALTA (The Agricultural Laboratory Testing Association), an organization of professionals dedicated to quality soil testing, accurate reporting, sound management advice, and information sharing. Many in this group manage private-sector soil test labs and the leadership of ALTA is very interested in working with the FRST team. We will be interacting with them by attending their annual meetings and other activities. Discussions with ALTA have already been instrumental to our work as we have learned that many soil test labs no longer make recommendations; they simply provide analytical results to the advisors who then make the fertilizer recommendations. Working with ALTA on the FRST project and decision tool will be iterative and critical to the integration of the private sector. We will also pursue other private-sector opportunities.

Once the decision support tool is ready for beta-testing, another 11-member stakeholder advisory committee will be developed consisting of two farmers, two CCAs, two commercial soil test lab personnel, two collaborators from FRST, two executive team members from FRST, and the programmer to provide continuous feedback on the development of the FRST decision tool. It will be critically important to also provide all collaborators the opportunity to provide feedback on the decision tool; the national soil fertility faculty must support the outcomes of the tool or it will not be promoted and/or used.

When the decision tool is developed, we will urge collaborators to provide local outreach to their farmers, CCAs, agency personnel including NRCS, private labs, and any other group involved in nutrient decision making. Assuming that many land grant institutions choose to use FRST in P and K fertilizer recommendation rates and promote the tool to user groups, we cannot assure that the outside user groups will use the tool, although there appears to be industry interest. This project is focused on harmonizing recommendations across land grant universities for soils within similar physiographic regions as a starting point.

3. The most obvious measures of accomplishments are the large national community of practice we have developed, the peer-reviewed journal articles published, the two symposia we were invited to present at Soil Science Society of America International meetings, and programming of the decision tool. These outcomes are and will continue to be available on our website (soiltestfrst.org). We expect to continue publishing and potentially providing more symposia. Once complete, the transference and use of the FRST decision tool will provide both the most important outcome and impact. The impact of journal articles will be followed by documenting the number of citations, downloads, and Altmetric Attention Score, which includes media mentions (e.g., social networks, mainstream news, public policy documents). To date, the FRST Project has published five papers in refereed journals, been featured in CSA News (the official member magazine for the ASA, CSA, and SSSA), and the CSA News developed a short promotional video for social media. Based on Altmetric scores, all articles have received outstanding attention (see summary below).

- Pearce et al. (2022) Defining relative yield for soil test correlation and calibration trials in the fertilizer recommendation support tool. https://doi.org/10.1002/saj2.20450
    - Altmetric Score of 9 (https://wiley.altmetric.com/details/129290529)
    - In the top 25% of all research outputs scored by Altmetric
    - High Attention Score compared to outputs of the same age and source (88th percentile)
    - #6 of 45 outputs of similar age from Soil Science Society of America Journal
- Slaton et al. (2022) Minimum dataset and metadata guidelines for soil-test correlation and calibration research. https://doi.org/10.1002/saj2.20338
    - Altmetric Score of 10 (https://wiley.altmetric.com/details/116200503)
    - In the top 25% of all research outputs scored by Altmetric
    - High Attention Score compared to outputs of the same age and source (90th percentile)
    - 4 of 30 outputs of similar age from Soil Science Society of America Journal

- Lyons et al (2021) Development of a soil test correlation and calibration database for the USA. https://doi.org/10.1002/ael2.20058
    - Altmetric Score of 4 (https://wiley.altmetric.com/details/119018070)
    - Good Attention Score compared to outputs of the same age and source (65th percentile)
- Zhang et al. (2021) Variation in soil-test-based phosphorus and potassium rate recommendations across the southern USA. https://doi.org/10.1002/saj2.20280
    - Altmetric Score of 16 https://wiley.altmetric.com/details/108142254)
    - In the top 25% of all research outputs scored by Altmetric
    - High Attention Score compared to outputs of the same age and source (88th percentile)
    - #4 of 25 outputs of similar age from Soil Science Society of America Journal
- Lyons et al. (2020) FRST: A national soil testing database to improve fertility recommendations. https://doi.org/10.1002/ael2.20008
    - Altmetric Score of 12 (https://wiley.altmetric.com/details/79000951)
    - In the top 25% of all research outputs scored by Altmetric
    - High Attention Score compared to outputs of the same age and source (81st percentile)
    - #41 of 187 outputs from Agricultural & Environmental Letters
- McCauly (2020) The FRST National Soil Fertility Database. Published in CSA News, June 2020
    - Altmetric Score of 18 (https://acsess.onlinelibrary.wiley.com/doi/10.1002/csan.20218)
    - Article received 28 tweets from 24 users with 82,011 total followers
    - 2-minute promotional video was circulated on social media.

4. Early into FRST we developed a robust website (soiltestfrst.org) that provides a robust repository of outreach and outcomes; it provides communications describing the activities, accomplishments, and impacts of the NRSP. At soiltestfrst.org, access to all our collaborators, many FRST presentations, two-page fact sheets and short videos that have or will continue to be developed for each relevant activity, links to our peer-reviewed publications, and a link to our decision tool when it becomes available are available. The soiltestfrst.org communicates the breadth and scope of this national soil fertility project as a NRSP. The impact of the FRST website will be tracked with Google Analytics. Journal and land grant university communications departments have been and will continue to be used to promote project efforts and accomplishments.

5. Mechanisms for distribution of project results are similar to the communication of project activities, accomplishments and impacts as we are distributing project results through the website (soiltestfrst.org) that archives activities into specific outputs: goals and objectives, funding, project team and collaborators, presentations, resources, and contact. The FRST project has already provided two symposia at two annual Soil Science Society of America meetings (2019 & 2021), as well as presentations at several other professional meetings, including CCA training, regional NIFA soil test meetings, and private sector venues, such as The Fertilizer Institutes

annual meeting. Many of these presentations are available through the website as are all our publications. We will continue to seek international, national, and regional symposia opportunities and use social media resources to promote project highlights. Currently, we are planning a series of webinar presentations for CCAs and soil test labs regarding FRST - the algorithms we are standardizing and the tool we are developing.

Every paper, presentation, and the website acknowledge our sponsors. Should we obtain NRSP support from Hatch MRF via SAES and NIFA, we would acknowledge them just as we have our current funders.

6. Data management has been central to the conceptualization and development of FRST. Our data storage, FRST decision tool, and collaborator data papers are within Ag Data Commons, which is part of the National Ag Library. AgCROS (Agricultural Collaborative Research Outcomes System), a USDA-ARS website that "provides information, data, and data resources links to some of the USDA Agricultural Research Service (ARS) Natural Resources, Genomics, and Nutrition efforts', is under the umbrella of Ag Data Commons. AgCROS is designed with the intent to provide agricultural research data to the public research and development community (https://agcros-usdaars.opendata.arcgis.com). Once the FRST legacy database is fully developed, it will be accessible to agricultural researchers.

Further we believe that data quality and curation is critical to the integrity of the FRST database. Since the beginning of FRST we have worked with Dr. Sylvie Brouder and the National Agricultural Library to ensure that our database ontology was appropriate. The majority of legacy data entered into the FRST has been obtained from refereed journals and other publications; we have to assume that the researchers have inspected their data prior to publishing for errors. The FRST team has taken every effort to ensure the data has been correctly copied and imported into the FRST database. For raw datasets that have been submitted, we also need to assume (and try to ensure by asking) researchers to only submit clean and correct data to the database. The legacy data is typically less complete than current data we are entering that ascribes to the minimum dataset categories that the FRST project delineated (https://doi.org/10.1002/saj2.20338). For data collected from ongoing and future trials, the minimum dataset guidelines for "required data" include measures of variance for the required soil test P and K values and yield data. The minimum dataset stablishes a protocol for scientists to share and publish raw data which will enable database users (e.g., researchers) to vet data quality with statistical analyses. We will continue to promote the minimum dataset as a set of guidelines for soil-test correlation and calibration research as one strategy of promoting and assessing data quality. We will register the FRST database with Ag Data Commons (National Ag Library), which will provide a citation under FRST authorship.

The FRST software engineer is performing checks in the program to ensure all datasets that are entered contain the minimum data required for inclusion, the data is entered in the correct format, and the metadata (county names, state postal codes, soil series, soil map units, soil textures, soil taxonomic names, etc.) are correct. He is using the SSURGO database to confirm the soil related information. For location checking, he has location information (state, county and FIPS codes) stored in the database which he pulled from U.S. Census Agency. Most of the checks are to ensure the data can be properly filtered/grouped and analyzed within the program.

We have discussed rating datasets to signify data quality. However, we are not sure how that information will be applied to the tool results other than reporting how many datasets are the top tier versus lower tiers. At this point, we need as much data as we can obtain. As far as rating datasets, we do not see that currently there is much to be gained. If in the future, though, we wanted to automatically generate database categories, the categories would probably be: Tier 1 – Datasets that contain all original summary and rep data; Tier 2 – Datasets that contain all original summary data, and; Tier 3 – Datasets that contain data that has been estimated (interpreted from graphs).

Finally, as stakeholders use the tool and filter datasets, they will have the ability to control which datasets they include. If an individual decides a dataset appears to contain data inconsistent with the related datasets, they will have the option to exclude it. At this point, it is their responsibility to justify the exclusion and we can offer them an option to report it to FRST so the dataset can be checked.

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NRSP Review (Submitted)

Project: Building Collaborative Research Networks to Advance the Science of Soil Fertility: Fer

Dates Covered 10/01/2023 - 09/30/2028

The following statement defines the mission of the National Research Support Projects (NRSP's):

NRSP Mission: National Research Support Projects (NRSPs) focus on the development of enabling and critical technologies (e.g., databases, cyberinfrastructure, on-line toolkits, reagents), support activities (e.g., collect, assemble, store, and distribute materials, data, resources or information) or the sharing of facilities (e.g., analytical equipment, lab, field) needed to accomplish high priority research.

Based on this mission, please rate the proposed NRSP using the following criteria.

	Satisfactory	Unsatisfactory
Mission:		
Consistency with the NRSP mission	◉	○
Relevance:		
Addresses and supports a high priority national issue	◉	○
Demonstrates clear and tangible benefits to the scientific community as a whole	◉	○
Clearly identified sponsoring beneficiary stakeholders	◉	○
Stakeholder involvement in project development, project activities, review, and/or management plans	◉	○
Technical Merit:		
Overall technical merit (sound scientific approach, achievable objectives, review, and/or management plans	◉	○
Potential for significant outputs (products) and outcomes with impacts	◉	○
Implementation Plan:		
Benchmarks for success clearly identified	◉	○
Management structure that adequately coordinates efforts of multiple participants	◉	○
Well-developed business plan that captures multiple sources of funding and leverages OTT MRF	◉	○
Funding plan that develops alternative funding sources to reduce OTT MRF in future years	◉	○
Efforts integrated with Extension, academic, or international programs	◉	○
Outreach, communications and assessment plan that communicates the program goals, accomplishments, and outcomes, and impacts	◉	○

Comments (Please add general and specific comments on strengths and weaknesses of the proposal, including specific revisions that would improve the proposal):

The initial review of the project entitled “Building Collaborative Research Networks to Advance the Science of Soil Fertility: Fertilizer Recommendation Support Tool (FRST)” identified potential weaknesses including:

1. the feasibility of standardized, regional recommendations,
2. the need for greater Extension education,
3. the need to address the underlying factors contributing to divergent soil-test-based fertilizer recommendations,
4. the need to evaluate data quality and include environmental risk factors in soil-test-based recommendations,
5. the need to engage the private agricultural industry using soil-test-based fertilizer recommendations for both agronomic and environmental nutrient management, and
6. the need for funding to pursue and sustain the project’s activities across time.

Revisions to the project proposal generally address the concerns identified from the initial review. We expect that some of these issues (e.g., how will the ag industry and end-users be engaged and greater Extension education activity) will require interaction with the scope of stakeholders to identify and develop strategies to address them, and Extension activity will ramp up when the decision support tool is available to showcase.
One specific area of growth for the project is to enhance the support and buy-in from the private soil testing sector, which is critical since private labs serve the majority of the acreage across the country. The description of how the private soil testing industry will be engaged and the role they will play in FRST is a bit weak. ALTA is mentioned but it is not clear how representative that organization is of the private soil testing industry. There is no representation from this group on the executive committee. There are some major regional, if not national, private testing labs that should be involved in the project. Representation from entities such as ServiTech, Midwest Labs, Brookside Labs, WayPoint, and A&L Labs should be actively sought. Likewise, the outreach efforts should be more explicit in how the FRST project will share results with the private sector. We expect this to be an area of growth and maturation as the decision support tool is developed and demonstrated.

The project does not address soil health measurements. At this point, that is probably best as there is little agreement on what measurements to take or what they mean and relate to crop productivity. We support the focus on fertilizer recommendations and the prospect of reducing fertilizer inputs as a primary benefit of the project. Other nutrients or soil health measurements can be added later and represents another area for project expansion.

The core team is represented across geographies of the conterminous US by faculty with responsibilities in all three land grant missions of teaching, Extension education, and research with the added perspective of faculty who manage agricultural service laboratories. The FRST effort is well-rooted and diverse with participation from most states and Puerto Rico.

There have been regional efforts to “harmonize” soil testing across state lines and the FRST project will provide structure to facilitate collaborations at the regional and national levels, which will be valuable. The demand for soil testing services has increased in the last 20 years despite a general lack of research supporting the development and validation of soil-test-based fertilizer recommendations. The proposal fits the NRSP guidelines and the financial request is modest. Overall, we find this project is timely, addresses the “Right Rate” - a foundational aspect of 4R Nutrient Management, and has the potential to be a highly successful program that provides a common theme to unite the work of faculty working in agronomic and environmental nutrient management and soil health.

Overall Recommendation: Approve

Cancel (https://www.nimss.org/review/my_reviews)

Report a Bug