

NRSP_temp9: NRSP-9 National Animal Nutrition Program

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Non-Technical Summary

The National Research Support Program 9 (NRSP-9) commonly referenced as the National Animal Nutrition Program (NANP) was conceptualized and implemented 15 years ago to address to lack of research resources for developing feed ingredient databases and mathematical models to predict nutrient requirements. The NANP is focused on an integrated and systematic approach to sharing, collecting, assembling, synthesizing, and disseminating science-based information, educational tools, and enabling technologies on nutrient needs of agricultural animals that will facilitate high-priority research across all domestic agricultural species. The beneficiaries of this research support project include students, scientists, educators, policy makers, research and regulatory agencies, industry professionals, and organizations associated with the production and welfare of agricultural animals. Downstream benefits of the research support are realized by agricultural producers and U.S. citizens, whose well-being is improved by the provision of a safe, healthy food supply. Accordingly, the NRSP-9 renewal has set forth 8 objectives to continue and refine NANP's development of research tools and communications needed by stakeholders to address animal nutrition questions and issues. We anticipate that the outcomes will be far reaching, including: the development of the real time data acquisition to keep the feedstuff information relevant over time. This will result in cost savings and minimize the environmental impact of animal production; expand the predictive capabilities of researchers and thereby increase whole-farm production efficiencies. These educational and modeling tools do not exist elsewhere; and future NANP forums will make stakeholders further aware of critical issues affecting livestock production, the environment, and human health.

Statement of Issues and Justification

Prerequisite Criteria

How is the NRSP consistent with the mission?

The impact statement of the NRSP-9 (aka The National Animal Nutrition Program or NANP) is focused on developing a forum to identify high-priority animal nutrition issues and provides an integrated and systemic approach to sharing, collecting, assembling, synthesizing, and disseminating science-based information, educational tools, and enabling technologies on animal nutrition that facilitate high-priority research among agricultural species. This aligns with the overall support activities of an NRSP. Initially, specific objectives were developed to support development of nutrient ingredient databases, animal nutrition modeling resources, and forums to help educate stakeholders on emerging issues (e.g., sustainability of livestock production; contributions of animal nutrition to human health, nutrition, and wellness); however, over the past 5 years, NRSP-9 has gone beyond the proposed objectives by developing new partnerships and plans for a long-term (self-supporting) business model. Off the top multistate research funds (OTT MRF) funding for the past 15 years has positioned NRSP-9 to become a leading resource for ingredient databases (big data) and animal nutrition models used by stakeholders. To remain a sustainable entity, a nonprofit (501(c)3) arm of the NANP was established. This will help the NANP to maintain relevant and dynamic in the future. Through these efforts, NRSP-9 will expand its footprint as a unified data repository and resource center for the animal nutrition research community specifically, as well as the broader animal research community, continue the training and development of future nutrition researchers in modeling techniques that decrease dependence on singular labor-intensive and expensive nutrition experiments, support the National Academies of Science, Engineering, and Medicine (NASEM) nutrient requirement series that serve as the basis for the entirety of nutrition research in the US, and enable scientists to more effectively and efficiently identify information needed to fill current knowledge gaps. Nutrient databases and models developed by NRSP-9 have significantly supported the sustainability of the NASEM nutrient requirement series. These resources go beyond the databases and models developed and they also include institutional expertise represented by the scientists working with NRSP-9 and the resources that have been leveraged. The NANP's relevance as a national need is evident in its broad scope and far-reaching implications. Animal nutrition directly impacts agricultural productivity, food security, and environmental sustainability across all regions of the United States. By focusing on optimizing animal nutrition and feeding management, NANP addresses concerns that are universal to livestock producers, environmentalists, and policymakers nationwide, and in fact, globally.

Linking nutrition with other areas of science has resulted in tremendous strides in our knowledge and ability to improve animal agriculture production efficiencies. For instance, a tremendous amount of new genetic information is now available, and large global projects are in progress to derive genomic prediction equations for key productive, nutritionally-linked traits such as feed efficiency. Defining nutrient requirements or nutritional responses as functions of the animal's genetic potential allows construction of diets more closely tailored to nutrient demands. Another example is linking nutrition with immunology to decrease antibiotic dependence and maintain good animal health and welfare. Also, NRSP-9 has become a coveted resource for providing scientific expertise and data/model assets to examine issues related to green-house gas (e.g., methane) mitigation and effects of animal nutrition on land, water and air. Recently, the NANP has developed a Climate-Smart Feed Management (CSFM) committee in conjunction with the Natural Resources Conservation Service (NRCS) to address holistically how diet formulation and nutrient management impact the environment and livestock production. These within- and cross-disciplinary linkages are crucial for many areas of animal science, and all contain some component that is grounded in nutrition. A better understanding of these linkages requires collecting and mining of large data sets. The data, data repository, and resources provided by NRSP-9 provide a critical foundation for these investigations and help to ensure scientifically sound, contemporary, and consistent information is available for researchers. By making the information publicly available, scientific progress will be increased through the work of a broader cross-section of the research community. Many of these research areas are expanding, and continued support from NRSP-9 activities will promote the efficient advancement of new knowledge. By providing globally accessible research and education tools, the NRSP-9 impact extends internationally, across sectors of the feed industry, and invests in future nutrition researchers. The NRSP-9 strives to keep ingredient databases and models digital, editable, perennial, and accessible. Again, recruiting contributions to the nonprofit arm of NANP will ensure the long-term sustainability of the project. Sources of funding for the nonprofit component of NRSP-9 are currently being explored. These will potentially include; subscriptions, fees for training workshops, sponsorships, and granting next-level data/model access.

How does the NRSP pertain as a national issue?

National Scope

Members of NRSP-9 currently encompass scientific expertise from the beef, dairy, poultry, swine, small ruminant, equine, and aquaculture industries from all regions of the U.S (see Appendix 1). In its activities, NRSP-9 has solicited external input from most U.S.-based animal science professional societies such as the Federation of Animal Science Societies, the American Dairy Science Association, the American Society of Animal Science, the Poultry Science Association, Equine Science Society, Comparative Nutrition Society, and World Aquaculture Society. Through this involvement, the NRSP-9 team has been able to interact directly with researchers, educators, and industry professionals from across the U.S. at annual professional society meetings. In addition, NRSP-9 has developed linkages with government agencies (e.g., the Natural Resource Conservation Service). The direct significance of NRSP-9 resources to stakeholders is underscored by the usage statistics for the website, which indicate the site garners 1,400+ pageviews per week from users throughout the United States and 165 other countries. During the one-year period extending from August 1, 2023-2024, the NRSP-9 website welcomed 19,091 (i.e., unique) users and there are currently 2,880 users who have registered to access the freely-available resources that NRSP-9 has developed. These data indicate that, even though the audience is already global, the full spectrum of potential site users has not yet been saturated. The utility of the site materials is evidenced by the fact that the average time spent per visit is increasing with the addition of new materials. Social media metrics indicate that NRSP-9 campaigns (Facebook, LinkedIn, Instagram, and X) are effective. From June 2022 until July 2024, social media audiences have increased from 66 to 1,586. In addition, audience growth in the respective social media outlets has increased from 30 to 130% during the last year. Collectively, these metrics suggest that the data and tools provided by NRSP-9 are of interest and are helpful to stakeholders nationally and internationally. We expect user engagement to increase substantially within the next 5 years, especially as the NRSP-9 offers greater integration and flexibility to engage with resources through direct implementation of data in third-party applications.

Governmental and non-governmental agencies around the U.S. are realizing and publicizing the value of animal agriculture to citizens. Nutrition is the most indispensable component of animal agriculture and one of primary economic importance regarding the production cost of animal-sourced foods. Without proper nutrition, animals will not meet their genetic potential, will not grow optimally, will not reproduce, will not be in optimal health and will be unable to efficiently provide societies with essential sources of food, fiber, work, and companionship. By assembling data on feed ingredients and animal performance, NRSP-9 has furthered knowledge of animal nutrition vital to improving food production efficiency, animal welfare, environmental impact, and farm economic viability. Through these planned activities, NRSP-9 will solidify its applicability as a unified nutritional information repository essential to animal agricultural stakeholders across the U.S. and the world.

Need

Attendance at symposia/workshops indicates a demand for animal nutrition knowledge, and a continued need for the NRSP-9 activities (from 2017 to 2024, over 700 individuals attended NANP modeling workshops). The continued need for the NRSP-9 research support activities is also evidenced by stakeholder interaction with the website and current research directions in animal science. As previously discussed, the NRSP-9 website attracts a substantial number of new users each week, indicating that stakeholder interactions with website resources are far from saturated and that stakeholders continue to find utility in the NRSP-9 research support efforts. Additionally, a number of growing research fields rely heavily on an accurate understanding of animal nutrient requirements. Nutrigenomics (the study of the interactions between diet and genetics) is a rapidly expanding field that promises the possibility of (1) delineating the relationship between diet, genetics, and disease; (2) developing feeds that can be matched to animal genotypes will allow more precise feeding programs, improved animal performance, increased feed efficiency, improved animal health, and enhanced animal welfare. Given the relatively low occurrence of certain health events, the accumulation of enough observations on specific health events to understand and address the disease is a challenge. Continued support of a data repository where observations can accumulate over time will provide an excellent resource for those interested in studying the interactions between nutrition and immunology. Immune responses can be manipulated by diet to decrease dependence on antibiotic use, while ensuring animal health, feed efficiency, and food safety. Recent concerns about foreign animal disease impacts on international trade (e.g., Avian Flu, African Swine Fever in China) and the security of our national production in conjunction with changes in antibiotic use in response to societal pressure underscore the imperative to understand the interaction of nutrition with immunocompetence fully. Dietary modification can be combined with other environmental factors to optimize immune response under various production conditions. Moreover, the onset of immunologic and production-related changes can be controlled by using dietary modification and there is opportunity to use immune response as a biologically meaningful index for specifying dietary requirements. Research outlining the effect of the environment on animal nutritional requirements has been going on for quite some time; however, the recent focus on projecting climate change effects on animal agriculture has reinforced the relevance of this research.

Each of these promising research areas has the opportunity to substantially enhance the sustainability, competitiveness, and profitability of the U.S. food production system. Each research focus also requires improved tools for estimating, understanding, and investigating animal nutrient requirements. As these disciplines continue to expand, relevant and cohesive nutrition research support efforts such as NRSP-9 will be essential to success. Additionally, it must be noted that any nutrition research, or research in other disciplines that have some base nutrient levels supplied to the animals used, begins with current NASEM nutrient requirement estimates for the various species. In the past 10 years in the 3 key professional journals in agricultural species in the US (Journal of Animal Science, Journal of Dairy Science, and Poultry Science), the NASEM requirement series for beef, dairy, equine, poultry, and swine are cited 11,529 times. Citations on a worldwide basis would be significantly greater given the international standard of the NASEM publications. Research related to an understanding of all aspects of the production of ever-improved animal genetics is in the US rests squarely on the NASEM requirement publications. It is recognized that the NRSP-8 (Building Applied Genomic Capacity for Animal Industries) might assist NASEM and NRSP-9 to apply -omics data to help define nutrient requirement models and improving nutrient utilizations.

The NRSP-9 provides essential material support to NASEM nutrient requirement subcommittees. Consequently, the impact of NRSP-9 is far reaching and any time an individual or researcher uses data or concepts from recent NASEM nutrient requirement documents the NRSP-9 has succeeded in supporting those specific activities. Though difficult to quantify, the need for NASEM documents and the supporting nutrient databases and models of nutrient supply and demand are exceedingly broad within animal research activities as well as in the practical applications of nutrient management and use of emerging precision technologies. Thus, the research support efforts of the NRSP-9 are an essential support network for NASEM and, consequently, the entirety of animal research. This culmination of accurately defining ingredient composition and modeling animal nutrient requirements is efficiently formulating animal diets. This will not only improve animal production efficiency, but will avoid deleterious effects on the environment.

Subsequently and recently, NRSP-9 has been able to leverage past accomplishments to develop a third working committee (Climate-Smart Feed Management [CSFM]) to work with the Natural Resource Conservation Service. This collaboration aims to increase awareness and implementation of livestock feeding management practices that address climate challenges. The agreement recognizes that livestock feeding management is critical to conserving natural resources and developing climate solutions, positioning NANP at the forefront of a national priority. The CSFM represents a significant opportunity to reduce greenhouse gas (GHG) emissions from the agricultural sector. The national impact of NANP's work extends beyond immediate environmental benefits. By improving feed management practices, NANP contributes to enhanced animal health and productivity, reduced feed costs for producers, and improved quality of animal products for consumers. These benefits resonate across the entire agricultural value chain, from rural farming communities to urban centers, underscoring the program's relevance to all regions of the country and beyond. The CSFM effort will also provide additional opportunities for the Feed Composition and Modeling Committees (e.g., documenting regional differences in feed nutrient composition and modeling how GHG emissions respond to nutrient inputs).

The relevance of NRSP-9 in the immediate future is also evidenced by current efforts to improve animal nutrient requirement models. Interactions with the committees of NASEM have provided a strong avenue of research support utility within NRSP-9. With the complete revision of the NASEM nutrient requirement of poultry, there exists substantial opportunity for NRSP-9 to facilitate efficient research efforts, most notably through enabling a more efficient paradigm for the continual update and maintenance of nutrient requirement models. In addition, new NASEM nutrient requirement revisions are being discussed (e.g., Fish and Shrimp, Companion Animals) that will provide an opportunity for NRSP-9 contributions through the provision of a standard platform for a feed composition database and the preservation of the feed composition data for use by researchers as well as the current and future nutrient requirement revision committees. Additionally, the NRSP-9 will capture and preserve the animal performance data collected and the model and software source code. Such efforts will negate the need for each committee to collect data, code, and models from scratch thus significantly improving the efficiency and speed of those nutrient revision efforts. Initial efforts toward this new structure have already been successfully enacted with the 2016 NASEM revision of Beef Cattle Nutrient Requirements and the 2021 NASEM revision of Dairy Cattle Nutrient Requirements. Moreover, the forthcoming NASEM revision of Poultry Nutrient Requirements, last updated 30 years ago, is the first to fully integrate the NANP Feed Composition database as a central source, thereby further expanding the reach of the NRSP-9 on the global stage. Although in the early stages, it is anticipated the NASEM Swine Nutrient Requirement revision will utilize NRSP-9 resources. Procedures developed to create and ensure the dynamic nature of databases and mathematical models have been presented in peer-reviewed journals and available on the NRSP-9 website. This template and data preservation can serve as a model for future improvements to nutrient requirement models. Furthermore, as beta versions of future NASEM software releases become available, NRSP-9 can provide modeling advice through rapid response beta-testing to decrease errors in the end product. By addressing administrative technicalities associated with the NASEM model updates, NRSP-9 efforts enable revision committee members to focus their efforts on improving the scientific representations of biology encoded within the models to reflect the current understanding of livestock nutrition rather than the mechanics of the models.

Rationale

Priority Established by ESCOP/ESS

The NRSP-9 supports the use and sharing of feed composition and animal performance data, resources for nutritional modeling, model code, and knowledge on feed analysis methods. The following sections highlight congruence between NRSP-9 overarching aims and specific objectives and the Updated Challenge Areas of the National Association of State University and Land Grant Colleges/Experiment Station Committee on Organizational Policy “A Science Roadmap for Food and Agriculture.”

Grand Challenge 1: We must enhance the sustainability, competitiveness, and profitability of the U.S. food and agricultural systems.

Agricultural sustainability, competitiveness, and profitability require: efficient livestock production; an economically viable production system; responsible environmental stewardship; and a socially acceptable product. Improved availability of feed composition and animal performance data will stimulate mathematical model development and nutrition research, which will help to establish more accurate estimates of nutrient requirements that stakeholders can use to construct more efficient diets. This will improve production efficiency by decreasing nutrient waste, thus improving economic viability. Decreasing feed waste will also increase land and water use efficiency. A better understanding the interactions between nutrition and immune responses will lead to improved animal health and welfare. Nutrition and global food system models will also benefit from increased accuracy of the animal components leading to economic models that are useful for making rational, sustainable food system choices. The planned expansion into other animal species will contribute to this goal, as aquaculture and small ruminants have shown remarkable promise in efficient production of high-quality human-edible protein and fill niches in the global food system that cannot be occupied by traditional production species.

Grand Challenge 2: We must adapt to and mitigate the impacts of climate change on food, feed, fiber, and fuel systems in the United States.

Climate change will negatively affect livestock production in the U.S., and maintaining existing levels of performance and efficiency will require adoption of costly mitigation strategies. Selecting the most cost-effective strategies will require models of animal performance that accurately represent stress responses. Preliminary work by NRSP-9 has demonstrated that some current nutritional models predict animal responses to heat stress with large bias. Data collected from the literature was used by NRSP-9 to improve the predictive accuracy of a production response model relative to heat stress. The model updates are detailed in a submitted publication and have been included in the National Pork Board- and the USDA-supported swine farm model, allowing unbiased predictions of responses to projected climate scenarios and more appropriately identify potential mitigation strategies. Similarly, the CSFM committee is integrating NRSP-9 resources to help livestock producers understand the impacts of diet/feed formulation on nutrient balance and animal production.

Grand Challenge 3: We must support energy security and the development of the bioeconomy from renewable natural resources in the United States.

Livestock consume most of the by-products from U.S. biofuel production. As biofuel processing methods evolve, the NRSP-9 feed database can be used to identify changes in feed composition to help researchers and industry professionals efficiently and economically use these products in diets. Additionally, the more precisely specified nutrient requirement models that will be developed as a result of NRSP-9 activities can help develop hypotheses about how these new products can be used to optimize animal performance. Efforts to improve animal efficiency also support this challenge, as more food can be produced per unit of energy expenditure, thus increasing energy efficiency and decreasing reliance on non-renewable resources. Additional synergy exists with respect to methane production from manure digesters. Improving predictions of nutrient digestibility also improve predictions of nutrient output in manure. As such predictions are helpful in determining manure methane yields, such improvements will lead to more robust predictions of the economics of methane production and help in managing functioning digesters to maximize energy yield.

Grand Challenge 4: We must play a global leadership role to ensure a safe, secure, and abundant food supply for the United States and the world.

By making these valuable datasets and nutrition research resources available in one location, NRSP-9 fostered development of international research efforts to produce safe and secure food. Many of the visits to the website are by individuals from developing countries where improved food security is paramount. NRSP-9 aims to continue this contribution to international development by launching the website in multiple languages. These types of global engagement and leadership are in anticipated to continue expanding in the next 5 years. The continued expansion of NRSP-9 resources in the small ruminants and aquatic species will further foster additional food resource development in such countries. Support of animal model development also provides better representations of the input:output relationships associated with animal-based food production that can be incorporated into global food models used to rationalize resources to maximize the quantity and quality of food produced. Training of graduate students, postdoctoral scholars, and young professionals in modeling techniques enhances our global leadership in educational training. It enables developing countries to benefit more quickly from research conducted in other parts of the world that they may not have had capability to initiate themselves.

Grand Challenge 5: We must improve human health, nutrition, and wellness of the U.S. population

Literature surveys, symposiums, and Summits conducted by NRSP-9 have identified gaps within animal nutrition knowledge. In identifying these gaps, NRSP-9 attempts to make recommendations for the provision of future research funds and therefore garner support for basic research that is applicable to livestock nutrition and could crossover into human nutrition. Similarly, the integration of NRSP-9 datasets with additional immunological parameters could foster an understanding of the links between diet and immune response, which will undoubtedly have applications in human nutrition and health. Animal nutrition can also be used to manipulate fatty acid composition of meat and milk products or to alter vitamin and mineral concentrations in outputted food products. Moreover, there exists a unique opportunity for animal agriculture to play an active role in helping to mitigate the effects of environmental change, which is also expected to directly benefit human health and wellbeing. Through this interaction, livestock and human nutritionists can work together to improve healthfulness of food products from livestock.

Grand Challenge 6: We must heighten environmental stewardship through the development of sustainable management practices.

Within a whole-farm system, feed production significantly contributes to environmental impact. Without accurate estimates of animal nutrient requirements, feed resources will almost always be provided at suboptimal levels, thereby reducing production efficiency and sustainability. By promoting a better understanding of methods to improve nutrient use efficiency, the NRSP-9 research support activities will improve nutrient requirement models that allow for precision feeding of livestock and decrease the environmental impact of food production systems. A better understanding and representation of digestion and metabolism will also support identification of novel mitigation strategies that might allow quantum environmental impact reductions.

Grand Challenge 7: We must strengthen individual, family, and community development and resilience.

An affordable, safe, and healthy food supply is vital to the development and resilience of individuals, families, and communities. As the climate changes, less water will be available for food production and the cost of feed will increase. With a substantial proportion of U.S. families below the poverty line, and a number of those routinely going hungry, providing an economical, healthy food supply is paramount. These situations raise the logical and controversial question: should we feed animals to feed ourselves? This question can be answered using a global food supply model provided that all system compartments are realistic. The NRSP-9 research support activities help develop the animal sub-models needed for a global food supply model thus allowing development of rational answers to the above question.

Relevance to Stakeholders

Stakeholder Identification

Our stakeholders include: (1) research scientists, teachers, and extension specialists in universities, colleges, veterinary medical centers, USDA, and other research and education institutions that conduct and disseminate animal-related research; (2) producers and agribusiness professionals who apply animal nutrition research results and who can help identify research needs (specialized producers, technical staff, extension agents, public health practitioners, and other allied agricultural and animal health practitioners); (3) organized volunteer groups and individuals active in advocating for animal nutrition and welfare; (4) organizations and individuals who represent groups with special challenges or problems (e.g. members of particular ethnic groups, low-income populations, niche markets); (5) Congress, which provides authorities and funding to carry out research, oversees effectiveness, and with whom we must communicate about research priorities; (6) White House policy officials and program managers; (7) federal agencies (research, education, extension, regulatory); (8) state and local government officials; (9) international governments; and (10) representatives of the media who communicate activities in research, education, and extension and who thereby play an important role in helping the public understand our roles.

Primary stakeholders are those directly affected by project activities (professionals in universities, governments, and industry). Secondary stakeholders are the entities who are indirectly affected by project activities (policymakers, representatives of the media, and those in interest organizations).

Stakeholder Involvement

The NRSP-9 was conceived at the request of stakeholders and their involvement is essential to its success. Input about website content and display, data availability, model prediction accuracy and calculation errors, software accessibility, and additional future areas of possible interaction has been received through the user feedback portion of the website and interactions at professional conferences. Stakeholders have been a regular part of NRSP-9 meetings, symposia, workshops, and Summits throughout the life of this project. Representatives from different stakeholder groups have attended NRSP-9 meetings including: (1) National Research Council's Board on Agriculture and Natural Resources (BANR); (2) major animal science professional societies (the American Society of Animal Science [ASAS], the American Dairy Science Association [ADSA], the Poultry Science Association [PSA]); (3) the International Life Sciences Institute (ILSI); (4) the United States Food and Drug Administration (FDA); (5) the Environmental Protection Agency (EPA); (6) the American Feed Industry Association (AFIA); and (7) the Natural Resource Conservation Service.

Current and future active participants in the NRSP-9 project (i.e., those developing, reviewing, and distributing new knowledge) will continue to be drawn from primary stakeholder groups, particularly research scientists, teachers, extension professionals, producers and industry experts, relevant organizations, and federal, state, and local governments.

Stakeholder Feedback or Review

NRSP-9 evolved from, and will continue to be based on, stakeholders' expressed needs, stakeholder discussions, and stakeholder ideas. Researchers, regulators, and industry groups uniformly identified an urgent need for updated nutrient requirements and models in the areas of poultry, swine, beef, dairy cattle and equine production. This need is ongoing but NRSP-9 has taken significant steps to address it. As NRSP-9 continues to expand databases, upload resources, and serve the needs identified by stakeholders, this effort will continue.

Stakeholder use of project outputs (i.e., publications, models, databases) has been determined primarily by website use statistics. Guests from BANR, FASS, ASAS, ADSA, PSA, ILSI, AFIA and FDA at NRSP-9 meetings have also provided direct, positive feedback on the community's efforts. Interactions at scientific meetings have also revealed great support from the research community. In the future, these feedback metrics can be expanded to include the extent of distribution and incorporation of the information and tools into other science and policy activities, attendance at NRSP-9 symposia and workshops, and by the publication citation indices. Website analytics and social media engagement are used as objective indicators to identify the value of information as directly assessed by stakeholders.

Renewal Justification

Although NRSP-9 has made great strides toward meeting the needs of stakeholders, new areas have emerged and there are substantial contributions that can still be made in both new and existing areas. In its current term, NRSP-9 has considerably improved availability of data and nutritional resources. Over 4 million records of feed composition from commercial laboratories have been collected and synthesized and are in the process of being made available for public download. This is an exceptionally valuable resource for the entire animal agricultural community. Industry professionals can consult tables to determine both the average and variance of nutrient specifications for over 400 ingredients and 137 nutrients. This aids in the construction of better-defined diets and will improve animal efficiency. NRSP-9 will continue efforts to collect commercial data and integrate it into the existing database so that the nutrient profiles of new ingredients can be documented and patterns in nutrient content over time can be identified. Currently, over 95% of the feed tonnage and 97% of the feedstuffs comprising that tonnage for nonruminant species are represented in the database and 90% of the feed tonnage and 85% of the feedstuffs comprising that tonnage for ruminant species are represented in the database; these values will all be in excess of 97% during the next project period. The greater value of an increased database, however, will not be an increase in the number of feedstuffs but rather an increase in the precision (the reduced error term for variation) of the values for each feedstuff which allows stakeholders to use less formulation overages needed to assure that blended premixes or diets meet the feed tag specs. This is an obvious cost savings and, from a biological standpoint, the reduction of overages reduces unused (i.e., waste) nutrients that enter the environment. The recent collaboration between NRSP-9 and NRCS, further highlights NRSP-9's focus on environmental sustainability.

The committee will continue to collect information from stakeholders regarding software and model concerns with the NASEM requirement programs and will correct software problems as they arise. Problem reports from the stakeholders that indicate potential deficiencies in the models will be categorized, investigated, and summarized for subsequent NASEM committees thus improving the speed of model improvement. NRSP-9 has now completed efforts to directly integrate the consolidated NANP feed composition database and the first-ever nutrient requirement model within the forthcoming revised report produced by the NASEM Committee on Nutrient Requirements of Poultry to establish the first integrated nutrient model for that species.

The NRSP-9 modeling and statistics resources will continue to be updated and examples of code for data and model analyses will be added to the web-based NRSP-9 nutrient models and made available to stakeholders. This improves research efficiency by providing the ready to use resources that researchers and graduate students in training need. The animal performance and animal nutrition and metabolism databases will be expanded with data from the current NASEM Dairy, Poultry and Beed committees). Making these data publicly available will greatly improve research efficiency and output as time will not be spent in multiple collections of the same data from the literature. By providing data and the analytical tools, great strides in knowledge generation should be achieved as more scientists join the effort to mine the existing data already present in the literature.

The NRSP-9 followed the two successful summits conducted in Washington D.C. in the spring of 2015 and 2019 with another summit in 2023-2024. As with past summits, a major focus of the 2023 NANP Summit was for policymakers to better understand the relevance of animal nutrition research to improving global food security and how to produce animal foods efficiently and sustainably. Two publications are available to highlight the outcomes from these Summits (<https://doi.org/10.33548/SCIENTIA1050> and <https://doi.org/10.33548/SCIENTIA1051>).

The series of Mathematical Modeling in Animal Nutrition workshop series has established itself as a crucial platform for training the next generation of animal scientists in data analytics and predictive modeling. Over the past 5 years (2019 to 2024), these workshops have consistently demonstrated their value and impact on the field, warranting continued support and expansion. The workshops have proven their success through a consistent track record of attracting a diverse audience of 60 to 100 attendees annually, including graduate students, faculty, and industry professionals. This steady attendance reflects the ongoing demand for advanced training in mathematical modeling within the animal nutrition community. Moreover, survey results have consistently shown high satisfaction rates among participants, with many indicating they would recommend the workshops to colleagues. The group plans to continue to hold symposia and modeling workshops (both introductory and advanced) at summer societal meetings to educate researchers, industry professionals, and students about feed composition concerns in addition to modeling techniques and approaches; these activities have expanded to include more species-specific activities during this renewal period and will further expand in the next renewal period. The symposium and workshop talks will continue to be recorded and made available through the NRSP-9 website and a symposium summary will be published. Additional educational efforts in Washington, D.C. and elsewhere will occur as opportunities arise to help improve research training and efficiency. Also, additional opportunities are being considered to showcase innovative and cutting-edge research efforts and assist with identifying research needs and structuring future directions within this NRSP-9 effort. It will be paramount that through NRSP-9 efforts, data and modeling projects keep abreast of new technologies

Implementation

Objectives

1. Develop an easily accessible and searchable feed composition database for the NASEM Swine Committee and integrate this database with others.
Comments: Current NASEM nutrient requirement publications have static feed composition data until revised by the next committee. The previous swine nutrient requirement publication and ingredient database were last updated in 2012. New ingredients, analyzed nutrient values, and automated feed/data screening procedures are now available.
2. Develop and foster relationships with commercial laboratories and organizations for ongoing submission of feed analyses and automated data screening methodologies. This would include expansion of ingredients to cover other species (e.g., horses, small ruminants, companion animals, aquatic, and wildlife/zoo animals).
Comments: The number of feedstuff analyses made by commercial laboratories dwarfs those made by academic laboratories. Access to that data has a tremendous effect on accuracy and precision of values but it must be vetted before inclusion. In addition, there is a repository of ingredient composition data not currently available from the literature or analytical laboratories.
3. Target solicitation of composition data for both nutrients that are not well represented or ingredients where data are lacking.
Comments: Ingredient composition data have expanded significantly since the inception of NRSP-9. These data can be used to fill in gaps that currently exist in the NANP ingredient database.
4. Expand multi-level training of modeling techniques to academic and industry nutritionists and graduate students across multiple species at professional meetings and develop online tools to provide modeling training and certification of users.
Comments: Recently trained nutritionists recognize their need and have readily embraced the professional society workshops that began during the present project. This will be expanded in scope (across species and areas of modeling) and depth. Modeling workshops and symposia have been very effective and well received. This represents a unique niche for NRSP-9.
5. Provide data and modeling resources in conjunction with scientific expertise to develop a Climate Smart Feed Management Committee.
Comments: The NRSP-9 is recognized as a leading resource for animal production modeling and ingredient nutrient composition information. These resources will be leveraged to create a working relationship with the Natural Resource Conservation Service.
6. Expand our social media platform to enhance client and stakeholder engagement.
Comments: Current communication platforms must include the most up-to-date modes of communication to maintain relevance and to facilitate rapid adoption and implementation of new knowledge. NANP has initiated a social media presence the last 2 years. Outreach to stakeholders in the future will be dependent, in part, on NANP's social media approach.
7. Development of an Application Program Interface (API) to allow users to directly engage with NANP Feed Composition records, which will also enable streamlined integration with modeling and CSFM committee efforts moving forward.
Comments: Access and utilization of the feed composition and modeling resources has been a priority for NRSP-9. Development of the API will improve engagement of stakeholders and permit expanded use-cases for direct injection of feed composition data into third-party applications.
8. Identify critical global issues related to animal nutrition to help facilitate open forums (professional meeting symposia, NANP Summits) for stakeholders.
Comments: Diversity of scientific backgrounds and unique academic advisors are ideal for developing topics/programming related to current emerging issues facing the animal nutrition industry and affecting human health.

Projected Outcomes

- Searchable feed database with real-time data acquisition. Comments: The development of the real time data acquisition will keep the feedstuff information relevant over time. This will result in cost savings and minimize the environmental impact of animal production.
- Relationships with commercial laboratories for ongoing submission of feed analyses and recruited feed composition data for new species. Comments: These commercial relationships represent the real-time data acquisition that allow better formulation decisions by commercial nutritionists and allow academic researchers to model year-to-year changes or national geographic differences in animal-related nutrient excretion and associated environmental impact. New species information will be used to help develop future NASEM nutrient requirement publications.
- Targeted solicitation of compositional data. Comments: The robustness of the NANP ingredient databases will be improved. This will attract more academic, industry, and government users.
- Expansion of modeling training at professional meetings and developing online tools. Comments: This will enable and expand the predictive capabilities of researchers and thereby increase whole-farm production efficiencies. These educational and modeling tools do not exist elsewhere
- Develop a Climate Smart Feed Management (CSFM) committee. Comments: The NRCS will utilize NRSP-9 (NANP) resources to develop a CSFM committee. This committee will provide programming to establish training for NRCS staff and identify approaches to more efficiently feed livestock and reducing impacts on the environment
- Expansion of social media presence. Comments: This increases the speed of information dissemination to stakeholders to facilitate rapid adoption and implementation of new knowledge.
- Development of an API. Comments: Stakeholder and user access to NANP data will be significantly improved by allowing direct integration into third-party applications. This will also enable NANP to provide dynamic feedback to users and better address specific user needs.
- Identify global issues related to animal nutrition. Comments: Future forums will assist stakeholders to becoming further aware of critical issues affecting livestock production, the environment, and human health. Overall Impact: Realizing the overarching aim to provide easily accessible and publicly available resources applicable to, and essential for, animal nutrition research will foster effective and efficient animal science-based research. Critical needs and "gaps" in information are clearly articulated throughout this proposal and meeting those needs will provide essential research support for a broad base of animal-related research programs.

Management, Budget and Business Plan

Management

The purpose of NRSP-9 is to support animal nutrition research and education among universities, SAES, NIFA, and ARS. It also connects FDA, EPA, NRCS, and the animal production and feed industries with the animal science community. The project leverages funding from USDA, FDA, and the feed industry, among others, to enhance the sharing of animal nutrition resources: tools, data, animal populations, and bioinformatics. Activities of NRSP-9 are managed and conducted by four formal working committees (see Appendix 1). These committees are:

1. Coordinating Animal Nutrition Committee (CC)

The Coordinating Animal Nutrition Committee (CC) represents the groups of animal nutritionists that coordinate, oversee, and integrate the selection process and activities of the Feed and Ingredient Composition Committee and the Modeling Committee. Members of the Coordinating Animal Nutrition Committee are appointed through a competitive process open to all scientists and educators from SAES and other cooperating organizations. The selection process is administered by the Program Leader and Lead Administrative Advisor (AA). The diverse structure of the Coordinating Animal Nutrition Committee has brought different species expertise, including swine, dairy, beef, poultry, equine, small ruminant, and aquaculture, to the whole project.

Appointments of committee members are made for multiple years with portions of the committee rotating off each year. The outgoing members coordinate with the new members and the Chair of the Coordinating Animal Nutrition Committee to ensure a smooth transition period.

2. Feed Composition Committee

The Feed Composition Committee is comprised of animal nutritionists that are selected through a competitive process administered by the CC and overseen by the Program Leader and AAs. The functions of this Committee are to identify and synthesize data and research resources in the area of feed composition, to foster communication among those collecting feed composition information, and to facilitate efficiencies and consistencies in data collection and maintenance. The Feed Composition Committee is working effectively with the NRSP-9 Modeling Committee to support needs regarding ingredient composition data as model inputs. The current 11 members of the committee represent all species and the following institutions from the U.S.: University of Illinois, Oklahoma State University, Pennsylvania State University, Auburn University, Cal-Poly – San Luis Obispo, University of Idaho, University of Georgia, University of Wisconsin-Milwaukee, Tuskegee University, and Phibro Animal Health (industry).

3. Modeling Committee

The Modeling Committee represents the groups of animal nutritionists that are selected through a similar process to the Feed Composition Committee. Functions of this committee are to improve the use of predictive technologies and tools, to utilize best available platforms, and to work with researchers to effectively share, combine, manage, and analyze models. The current 15 members of the committee represent all species and the following institutions: Virginia Tech University, Michigan State University, Washington State University, Texas A&M University, University of California - Davis, the University of Florida, North Carolina State University, and the University of Guelph, Agriculture and AgriFood Canada, University of Georgia, Langston University, South Dakota State University, and RUM&N Consulting (industry).

4. Climate-Smart Feed Management Committee

Recently, NRSP-9 developed an agreement with the Natural Resource Conservation Service to form a third working committee. The primary role of this committee will be to provide accessible and user-friendly feed and animal nutrition information for conservation professionals; and, deliver targeted educational and training opportunities for various stakeholders. Currently, there are 12 members representing: Texas A&M University, USDA-ARS, University of Nebraska, South Dakota State University, University of California-Davis, Oklahoma State University, University of Minnesota, University of Connecticut, and the World Wildlife Fund.

The feed composition database, nutrient requirement models, and animal performance information of the four initial species (swine, beef, dairy, and poultry) were established during previous projects. In the renewed project, at the request of stakeholders, data and resources of three additional species (e.g., small ruminants, horses, and aquatic species) began to be collected, assembled, and developed. Similar efforts are currently ongoing for companion animals. The NRSP-9 committees will take advantage and coordinate with existing multi-state committees that have elements of nutrition associated with their work. It is anticipated that efficiencies will be gained from close collaboration with the work of related multi-state committees and NRSP programs. In addition, during the next 5 years, an informal website and communications advisory group from any committee members with that interest and expertise will be formed to facilitate more rapid and thorough activity in those areas; further, an executive committee within the Coordinating Committee will be established to provide greater assistance to the overall program chair.

Administrative Advisors

Administrative Advisors will provide policy guidance to the CC and work closely with the NIFA Representative (Program Leader) on administrative, programmatic, and budgetary matters. The current Administrative Advisors are Lesley Oliver (Southern; University of Kentucky), Richard Rhodes (North Eastern; University of Rhode Island), Bret W. Hess (Western; University of Nevada-Reno), and Joleen Hadrich (North Central; University of Minnesota).

NIFA Representative

The National Animal Nutrition Program Leader serves as the NIFA representative to the project. The Program Leader is responsible for overall leadership of the program and works closely with the Committee Chairs and Administrative Advisors. Other responsibilities of the Program Leader include providing liaison with the Agriculture and Food Research Initiative (AFRI) Competitive Grants Program, serving as USDA link to international animal nutrition activities, providing linkage to other programs, and being an advocate for animal nutrition research activities within the USDA.

Reporting

The Coordinating Animal Nutrition Committee will prepare an annual progress report that reviews project accomplishments and outlines future plans that will be uploaded to NIMSS. Publication of information and technologies will be through the NRSP-9 website (<https://animalnutrition.org>), peer reviewed journals, and various media platforms to provide the widest public access to the benefits of the outcomes fostered by this project.

Budget and Business Plan

Budget

The budget request for NRSP-9 for FY 26 through FY 30 is \$1,591,00 from Multistate Research Funds (**Supplementary Table 1**; average of \$318,200/year). The total estimated budget for NRSP-9 project is \$55,446,685 (**Supplementary Table 2**; average of \$11,089,337 per year, though each year differs), which represents significant leveraging (**Supplementary Tables 3 and 4**) of MRF. Requested MRF to support NRSP-9 has and will continue to represent significant leverage of funding to support critical research structure activities, nationally.

Shared and in-kind costs from the members' institutions and industry will average \$7,410,137 (average) per year and total \$37,050,685 (**Supplementary Tables 2 to 3**). Commitments and/or willingness to provide financial or in-kind support have been made by representatives of the feed industry, the federal government, and other organizations. These organizations have expressed willingness to provide support to the NRSP program at a level that is feasible under constrained budget scenarios and that results in regular measurable outcomes to justify those investments. Resources from the U.S. feed industry in the form of feed composition data represent significant leverage. Approximately 2.7 million records of feed composition data from commercial analytical labs have been donated to the NRSP-9 feed databases. Ongoing submissions are being solicited and permanent relationships for data submissions from multiple commercial entities are anticipated with an expectation of yearly submissions of more than 200,000 records (**Supplementary Table 3**). Leveraged and anticipated future grant support associated with the NANP totals \$16,805,000 and averages \$3,361,000 per year (**Supplementary Table 4**).

In summary, requested MRF funding constitutes approximately 2.87% of the total project funding, with the other 97.13% of the support anticipated to come from industry and federal agencies in the form of grants or agreements and from public institutions and industry as in-kind support. This funding request reflects what is projected to be required to complete the current void in nutrition research support information and technology and then to continue the information access and modeling capabilities already developed by NRSP-9. The feedstuff information gaps that previously existed for NASEM nutrient requirement revision committees have been filled but will be outdated over time. Continual genetic change in crop cultivars coupled with genetic progress in animals and environmental change mandate dynamic and continued updates in the feedstuff database coupled with increasingly sophisticated models to estimate nutrient requirements across a varied production landscape. The foundation for those capabilities has been put in place by the development activities of the NRSP-9 committee for the feedstuff database and initial models for some stages of production for many species coupled with the training activities of the next generation of research and industry nutritionists in modeling. Additionally, the plan of the current NASEM poultry revision committee to tie the final publication to the NRSP-9 database in real-time rather than publishing innumerable pages of feedstuff data that is soon outdated points both to the realization of the need for current data and to the ongoing need for the NRSP-9 feedstuff database. The growing recognition of the value of this foundation sets the stage for others to assume greater responsibility for future funding and/or carrying out these activities and is the basis for the optimism of increased grant support evidenced in the proposal. With the continued development of models for additional production scenarios and species and the constant evolution of feedstuff nutrient profiles, the ongoing need for NRSP-9 activities is evidenced. Strong networks with governmental, industrial, and nonprofit communities have been built through the NRSP and a broad base of supporters is beginning to express interest in partnering to carry out the work in the future and/or to compensate the program for access to the developed materials.

Budget Justification

The proposed budget is based on making continued critical investments in research-support activities that address the agricultural, environmental, societal, and economic challenges facing our nation. These investments are aimed at building capacity toward improved effectiveness of our research programs. The budget is also designed to help strengthen our national infrastructure of feed and modeling information to achieve greater levels of efficiency and positive impact in the animal nutrition research arena.

This MRF budget request represents a mean increase of \$105,200/year in the proposed budget compared with the previous project budget. However, this increased investment is meritorious because of the high degree of positive impact associated with the committee activities. In fact, every time someone uses a recent NASEM nutrient requirements publication, the NANP-NRSP-9 is there, in the background, facilitating the quality work that results in those critical research and industry-supporting documents. Additionally, the NANP-NRSP-9 facilitates significant leveraged funding as indicated above and described in the **Supplementary Tables 2, 3, and 4**.

The requested MRF funding is to support the facilitation activities of the Coordinating, Feed Composition, and Modeling committees and the newly formed Climate Smart Feed Management Committee and will not be used to directly fund research programs. The funding is used for the support of all the outlined coordination activities, including working meetings, travel, synthesis of information, editing, integrating and providing technical and other resources, and maintaining communication among committees and with outside collaborators. Funding will also be for salaries, travel, supplies, and publication expenses as specified in supplementary tables.

Aside from funds to support the committee activities, priority budget items reflected in this proposal are for support for website maintenance and data management, a modeling coordinator (post doc), and social media maintenance and expansion, administrative support, and NASEM nutrient requirement activities support.

The NRSP-9 has endeavored to be fiscally responsible with its current budget and expects to continue to improve its fiscal accountability in the future. Strict policies were designed and put in place for consensus approval of the Coordinating Committee for every expenditure of significance requested.

Evidence from the current funding cycle demonstrates the parsimonious budgetary decisions of NRSP-9 members. These policies are anticipated to be retained and the NRSP-9 is committed to being a good steward of funds requested for a powerful return on the investment.

Types of Expenditures

Salaries are for professional and technical support staff for developing and distributing materials and for data input and operation of the database and models. Salaries of committee members and collaborators are contributed by the participating institutions. Supplies include materials to be shared with the Feed Composition, Modeling and Climate Smart Committee members, computer supplies and software for maintaining databases and computer information servers, shipping costs, postage, and communications activities. Website and data management expenditures reflect the cost of the planned updates and NRSP-9 implementation of website features and resources as outlined in the contracts with the web development company (Surface 51) that has partnered with NRSP-9 since 2018. Funds are also requested to support travel of the Coordinating Committee members to regular in-person meetings of their committees for development of the research support materials and models. The geographic and institutional diversity of the committees enhances the thought process of the committee but does require an every-other-year face-to-face meeting yearly to actualize the synergism that is possible from the diversity.

See attachment **Supplemental Tables 1 to 4** for budget details.

Business Plan

The Chair of the Coordinating Animal Nutrition Committee will work with Chairs of the Feed Composition, the Modeling and Climate-Smart Feed Management committees to prepare annual budget requests and reports. Allocations will be reviewed annually at the in-person meeting of the Coordinating Committee and distributions will be revised, if necessary, by the Program Leader and the four Regional Administrative Advisors. Upon approval of specific activities or projects for the Feed Composition and Modeling committees by the Coordinating Committee, project costs will be paid through the host institution. The NRSP-9 committees are continually soliciting input from national and international industry and academic partners regarding the feed ingredient databases and animal models. Although effort has been made, it is difficult to predict exactly how much feed composition and animal biological performance data will be donated per year and how many resources will be invested to construct, maintain, and update the databases and models.

Integration

Leveraged funding:

In the financial world, leveraging often is defined as helping both the investor and the firm to operate. Leveraging is depicted by a small initial investment to gain a high return in relation to one's investment. In regards to the NRSP-9, leveraging helps both the NRSP-9 activity and the greater community at large (i.e., university systems, industry, government and nonprofits). In the case of NRSP-9, initial investments have leveraged a tremendous return and are anticipated to continue to do so through this renewal request. **Supplementary Table 5** provides examples of funding leveraged from multiple sources over past years of the NRSP-9 project.

The funds leveraged by NRSP-9 to support animal-nutrition research are significant. A total investment of \$1,065,000 over the current 5-year period and \$1,125,000 over the previous 5-year NRSP-9 project period has leveraged additional resources valued at approximately \$91,540,691 resulting in a total of \$90,837,391 available to support NRSP-related national animal nutrition research effort – a sum that is more than 40 times the original NRSP investment during this time frame, which is in line with projected leveraged associated with our currently proposed renewal (**Supplementary Tables 2, 3, and 4**). Of particular note, are the feedstuff sample analyses received from industry labs. Currently, over 95% of the feed tonnage and 97% of the feedstuffs comprising that tonnage for nonruminant species are represented in the database and 90% of the feed tonnage and 85% of the feedstuffs comprising that tonnage for ruminant species are represented in the database. Continual increases in database size and filtering capabilities allow stakeholders to refine the mean nutrient values and the variation associated with those mean values for the particular feedstuffs that they are using which have tremendous value. An increase in the precision (the reduced error term for variation) of the values for each feedstuff allows stakeholders to use lower formulation overages to assure that blended premixes or diets meet the feed tag specifications. This is an obvious cost savings and, from a biological standpoint, the reduction of overages reduces unused (i.e., waste) nutrients in the animal excretion and minimizes the environmental impact of animal production.

Leveraging Partners

NRSP-9 has created the capacity to attract additional resources to support animal nutrition research from a broad base and a wide range of partners. Partners contributing additional funds and data of value in support of NRSP-9 national animal nutrition efforts include the feed industry, private foundations, private non-profit organizations, professional societies, and government agencies.

Beneficiaries of Leveraging

Beneficiaries of the products and funding leveraged include researchers, educators, students, animal producers, feed and animal agriculture industries, federal agencies, advisory organizations, and the general public. The work conducted and stimulated by NRSP-9 is truly a “public good” and as such is exemplary of the productive and appropriate use of public funds.

Outreach, Communications and Assessment

Audience

The stated beneficiaries of this research support project include students, scientists, educators, policy makers, research and regulatory agencies, industry professionals, and organizations associated with the production and welfare of agricultural animals. Downstream benefits of the research support are realized by agricultural producers and U.S. citizens, whose well-being is improved by the provision of a safe, healthy food supply, as well as the spill-over benefits of improved innovation and science.

Engagement of Stakeholders

Stakeholder engagement is enabled through member selection and participation in the NRSP-9 support activities in addition to member attendance at professional society meetings and user interactions with specific NRSP-9 resources via our website. The coordinating, modeling and feed composition committees each have one or more representative(s) from each species group included in the proposal. These experts were selected from around the country to ensure representation of all U.S. regions. As these members include research scientists, educators, and policymakers, many of the target beneficiary groups are directly represented in the daily decisions of NRSP-9.

Solicitation of and user participation through the website is also critical to the involvement of stakeholders in NRSP-9 research support activities. This occurs both actively, through inquiry submissions and polling of users through the NANP website, and passively, through tracking of website user statistics to quantify and improve digital resource use. Involvement in professional society meetings and conferences allows for direct interaction between NRSP-9 members and external stakeholders that has proved useful for identifying crucial research support areas and targeted website improvements. Dissemination of NANP news events and development occurs through robust social media interactions (i.e., LinkedIn, YouTube, X [formerly Twitter], and Facebook) providing diverse communication platforms through which stakeholder engagement and feedback is encouraged. By identifying key areas of focus within or across species, stakeholders can help steer the direction of NRSP-9 research support efforts to best match their needs.

Evaluation methodology

Accomplishments and impacts of NRSP-9 will be measured directly by the level of success in accomplishing the goals and by meeting the deliverables set out in the Strategic Plan. Reports of research support activities through commonly viewed channels such as peer-reviewed journals will be tracked and evaluated in terms of impact. As such, the number **(Supplementary Table 6)** and quality of publications (e.g., citation index) is a common measure of both research support accomplishments and outreach efforts to the community. The first seven peer-reviewed manuscripts in Table 2 (those published 2015-2017) have been cited 67 times by colleagues in their research efforts. The impact of the novel video-accompanied publication is demonstrated in Figure 1 (see attachments). These two publications summarize the ASAS workshop publications and presentations (see Appendices 3 and 4 for complete listing of workshop publications and presentations):

- Tedeschi, L. O., D. P. Bureau, P. R. Ferket, and N. L. Trottier. 2021. ASAS-NANP SYMPOSIUM: Mathematical modeling in animal nutrition: training the future generation in data and predictive analytics for sustainable development. A Summary. *J. Anim. Sci.* 99 (2):1-3. doi: 10.1093/jas/skab023
- Tedeschi, L. O., H. M. Menendez, III, and A. Remus. 2023. ASAS-NANP SYMPOSIUM: Mathematical modeling in animal nutrition: Training the future generation in data and predictive analytics for sustainable development. A summary of the 2021 and 2022 symposia. *J. Anim. Sci.* 101:skad318. doi: 10.1093/jas/skad318

Members of NRSP-9 also evaluate the accomplishments and impacts of the research support by monitoring stakeholder usage of digital resources (e.g., view of NANP recorded media, NRSP-9 website user tracking statistics, and social media engagements). By relying on stakeholder usage metrics, NRSP-9 members get a more accurate and authentic understanding of the usefulness of different research support approaches. Google Analytics metrics like visits, unique visitors, and pageviews help assess the magnitude of use while metrics like average time per visit and pages per visit help indirectly determine the potential impact of these different website components. Users who find value in a page divert more time to that resource. By relying on stakeholder usage metrics, NRSP-9 members get a more accurate and authentic understanding of the usefulness of different research support approaches. Location use statistics help identify the global impacts of NRSP-9 while the proportion of new users helps to identify the saturation of NRSP-9 utility within the stakeholder community. An example of the value of the revised website is provided in **Supplementary Table 7**. There was a 187% increase in new website users in 2024 compared to 2019. Also, 2023-2024 saw an engagement of users from 170 countries compared to 58 countries during the 3 year period from 2018-2021 (see Figure 2). In addition to the internal and ongoing monitoring of project activities, an external evaluation of the entire program will be conducted in Year 3 of the program to ensure that activities are meeting program objectives.

Developing Communication

The original NRSP-9 proposal listed several methods that will be adopted to communicate updates and research support activities to stakeholders. These included: public meetings, workshops, web conferencing, webinars, social media engagements, workshops, website input and feedback, needs assessment, surveys, focus groups, advisory bodies, listening sessions, and interviews. Of these suggested mechanisms, the group has relied heavily on website input and feedback and public meetings.

Website feedback elements are usually linked to specific projects and program areas whereas a social media presence enables cross-discipline engagement to meet stakeholders in a familiar environment. Website feedback allows users from around the world to provide input on website structure, NRSP-9 project directions, or other areas soliciting input. Forums are typically a good way to solicit user feedback as they provide a durable listing of comments and do not require substantial sacrifice on behalf of the user to participate. Public meetings include national conferences and professional society meetings. These events are also convenient ways to garner user feedback as, typically, stakeholders are already planning to attend, and their participation does not require an additional draw on time and resources. Finally, workshops or symposia typically involve a small number of stakeholders participating in brief instructive courses or viewing a series of brief seminars. These are typically valued events for stakeholders because of the small participation size and the likelihood of valuable skill and knowledge acquisition. From these distribution channels, the group was able to dispense information about NRSP-9 activities to stakeholders and simultaneously receive feedback on the focus and direction of research support. More recently, engagement has occurred through the NRSP-9 on YouTube, JoVE, and a presence on social media platforms, including LinkedIn, Twitter, Facebook, and ResearchGate. In addition, NRSP-9 has expanded a previously developed web-based global expert network to facilitate interactions among researchers within the field and in other scientific disciplines. This network will enhance communications and contributions of animal nutrition researchers to the science of nutrition and to other areas that are seeking animal nutrition expertise.

Distribution Mechanisms

The primary distribution mechanisms used by NRSP-9 are digital in nature, including the website, social media platforms, and peer-reviewed publications, with an emphasis on open access resources to ensure global engagement of stakeholders. Results are also shared at professional society meetings and through the annual and midterm reports available online in NIMSS. Website updates are available in real-time to ensure the primary means of interacting between the NRSP and its stakeholders is current and useful. At professional society meetings, NRSP-9 members have given poster presentations, run informational booths, conducted symposia and workshops, and demonstrated the website utility to stakeholders. Reports available online succinctly detail the accomplishments and impacts of NRSP-9 on a yearly basis.

Past Successes

NRSP-9 is a novel forum for national collaboration and resource sharing was developed. As a result, NRSP-9 leveraged funds from the National Academies to create the only functional, nationally coordinated approach to support animal nutrition research, modeling, and feed data efforts. NRSP-9 is recognized as the national public forum and key source of expertise supporting the national animal nutrition research agenda. In evidence of this status, NRSP-9 was invited by the ILSI to participate in a workshop to identify and address topics related to plant composition. This workshop brought together experts in animal nutrition, plant breeding, worldwide. NRSP-9 also has been welcomed to work with ILSI's Crop Composition Database Working Group. The global impacts of NRSP-9 were further evidenced by requests from and interactions with representatives of organizations in China (i.e., Director of the Ministry of Agriculture Feed Industry Center in Beijing China and professor at China Agricultural University) and Europe (i.e., French National Institute for Agricultural Research, [INRA], the French Agricultural Research Center for International Development, [CIRAD], French Association for Animal Production [AFZ] and the Food and Agriculture Organization of the United Nations [FAO]) to invite collaboration and complementary efforts.

The 2023 NANP Summit took place at the National Academy of Science Building, in Washington DC on Wednesday, April 12, 2023. The stakeholders that were invited included: Animal commodity groups, Agriculture Committee staffers, USDA leadership, members of CFAR, AFIA, Agricultural Experiment Station leaders, NAS, FFAR, and Governors Council. The mission of the summit was to evaluate the use of animals to sustainably provide for healthy human diets. Speakers from across the county presented on livestock sustainability, challenges of world food security, alternate protein sources, impact of livestock on the environment and climate change, use of life cycles assessment and role of animals in future food systems. At this Summit we also hosted a Graduate Student Poster Competition. There were 16 abstracts submitted, from which 6 students were selected to receive a scholarship to attend the Summit and present their work in the form of a poster. Post Summit publications are in the process of being produced and will be widely circulated when finished.

A symposium aimed at bringing scientific communities from the American Society of Animal Science (ASAS) and the American Society of Nutrition (ASN) took place in 2018 to spur exchange of information on data acquisition and analytics for nutrition. This symposium, with attendance by 97 international participants, was extremely well received with the expressed desire for actual exposure, specific tools, and hands-on training in future symposia.

Modeling workshops have become a sought-after forum for exchanging of information and developing capabilities among students, university researchers, and industry professionals. Conducted yearly at the American Dairy Science Association (ADSA) annual meetings, these workshops have received tremendous interest. From 2019 to 2024 there have been 64 workshop and symposia presentations at national ASAS and ADSA (this number would also include the 9th Workshop on Modeling Nutrient Digestion and Utilization in Farm Animals; see Appendix 4). In conjunction with these presentations, 20 peer-reviewed articles were published. These articles have been cited 233 times and viewed in excess of 38,000 times (Appendix 3)

In addition to substantial evidence of growing national and international awareness of the NRSP-9 efforts, website data also clearly document stakeholder use of and interaction with website components. Key research support accomplishments over the current timeframe include the release of expanded searchable feed composition and animal performance databases; and posted summaries and links to modeling and statistics resources. These resources represent the four most popular pages on the website. During June of 2024, the collective feed composition database and associated resources received 1,357 pageviews (598 unique users) and the modeling database and associated resources received 417 pageviews (281 unique users), and the NASEM nutrient requirement model pages received 247 pageviews (196 unique users). Overall, the digital resources provide a robust system of integrated platform systems that permit NRSP-9 resources to be easily updated and available to global stakeholders while engaging them directly to enhance and improve committee efforts.

Future Additions and Activities

The current project expanded the focus to include aquaculture species, small ruminants, and horses. This resulted in a wider audience, including stakeholders interested specifically in these species. As we continue to expand our focus, new experts will be recruited to serve as committee members to appropriately represent the needs and interests of these new areas of focus. Two areas of consideration are individuals with capabilities in the “big data” area and individuals with a greater systems environmental impact understanding that incorporate animals into the whole production system (e.g., intensive vs extensive production systems, soil type and cropping decisions) to understand nutrient flow. International impact is already evident from website statistics and symposia/workshop attendance but that will be further enhanced by the presentation of our efforts at international meetings; a scheduled presentation at the 9th Workshop on Modelling Nutrient Digestion and Utilization in Farm Animals (attended by individuals from 17 countries) will broaden our exposure and will build new connections for collaboration in modeling research. In addition to broadening the audience, the next phase of NRSP-9 will focus heavily on soliciting stakeholder participation in the user feedback forum and increased attendance at meetings to gather feedback from stakeholders on valuable areas of focus for research support.

During the proposed future work of NRSP-9, performance measures that are in place will be monitored, the quantity and impact of publications will be measured, and stakeholder feedback will continually be assessed as components of an evaluation methodology. With the wider audience associated with inclusion of additional species, members plan to continue relying on website input and feedback, public meetings and workshops as communication methods; however, efforts will be made also to utilize additional, more interactive communication approaches such as webinars and social media activity.

Ingredient database and mathematical modeling projects will embrace AI where/when appropriate. This could include developing a chatbot for NRSP-9 that could use specific publications to train it and make it available to stakeholders. It is anticipated that the collaboration with NRCS will continue to develop. NRCS will become, in part, a repository NRCS evaluation tools and modeling resources.

The creation of the NANP nonprofit component (501(c)3) completed in 2023 will provide a platform for NANP to explore recruiting industry and non OTT MRF funding moving forward.

Literature Cited

Outreach Plan

Audience

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- Tedeschi, L. O., D. P. Bureau, P. R. Ferket, and N. L. Trottier. 2021. ASAS-NANP SYMPOSIUM: Mathematical modeling in animal nutrition: training the future generation in data and predictive analytics for sustainable development. A Summary. *J. Anim. Sci.* 99 (2):1-3. doi: 10.1093/jas/skab023
- Tedeschi, L. O., H. M. Menendez, III, and A. Remus. 2023. ASAS-NANP SYMPOSIUM: Mathematical modeling in animal nutrition: Training the future generation in data and predictive analytics for sustainable development. A summary of the 2021 and 2022 symposia. *J. Anim. Sci.* 101:skad318. doi: 10.1093/jas/skad318

Members of NRSP-9 also evaluate the accomplishments and impacts of the research support by monitoring stakeholder usage of digital resources (e.g., view of NANP recorded media, NRSP-9 website user tracking statistics, and social media engagements). By relying on stakeholder usage metrics, NRSP-9 members get a more accurate and authentic understanding of the usefulness of different research support approaches. Google Analytics metrics like visits, unique visitors, and pageviews help assess the magnitude of use while metrics like average time per visit and pages per visit help indirectly determine the potential impact of these different website components. Users who find value in a page divert more time to that resource. By relying on stakeholder usage metrics, NRSP-9 members get a more accurate and authentic understanding of the usefulness of different research support approaches. Location use statistics help identify the global impacts of NRSP-9 while the proportion of new users helps to identify the saturation of NRSP-9 utility within the stakeholder community. An example of the value of the revised website is provided in **Supplementary Table 7**. There was a 187% increase in new website users in 2024 compared to 2019. Also, 2023-2024 saw an engagement of users from 170 countries compared to 58 countries during the 3 year period from 2018-2021 (see Figure 2). In addition to the internal and ongoing monitoring of project activities, an external evaluation of the entire program will be conducted in Year 3 of the program to ensure that activities are meeting program objectives.

Developing Communication

The original NRSP-9 proposal listed several methods that will be adopted to communicate updates and research support activities to stakeholders. These included: public meetings, workshops, web conferencing, webinars, social media engagements, workshops, website input and feedback, needs assessment, surveys, focus groups, advisory bodies, listening sessions, and interviews. Of these suggested mechanisms, the group has relied heavily on website input and feedback and public meetings.

Website feedback elements are usually linked to specific projects and program areas whereas a social media presence enables cross-discipline engagement to meet stakeholders in a familiar environment. Website feedback allows users from around the world to provide input on website structure, NRSP-9 project directions, or other areas soliciting input. Forums are typically a good way to solicit user feedback as they provide a durable listing of comments and do not require substantial sacrifice on behalf of the user to participate. Public meetings include national conferences and professional society meetings. These events are also convenient ways to garner user feedback as, typically, stakeholders are already planning to attend, and their participation does not require an additional draw on time and resources. Finally, workshops or symposia typically involve a small number of stakeholders participating in brief instructive courses or viewing a series of brief seminars. These are typically valued events for stakeholders because of the small participation size and the likelihood of valuable skill and knowledge acquisition. From these distribution channels, the group was able to dispense information about NRSP-9 activities to stakeholders and simultaneously receive feedback on the focus and direction of research support. More recently, engagement has occurred through the NRSP-9 on YouTube, JoVE, and a presence on social media platforms, including LinkedIn, Twitter, Facebook, and ResearchGate. In addition, NRSP-9 has expanded a previously developed web-based global expert network to facilitate interactions among researchers within the field and in other scientific disciplines. This network will enhance communications and contributions of animal nutrition researchers to the science of nutrition and to other areas that are seeking animal nutrition expertise.

Distribution Mechanisms

The primary distribution mechanisms used by NRSP-9 are digital in nature, including the website, social media platforms, and peer-reviewed publications, with an emphasis on open access resources to ensure global engagement of stakeholders. Results are also shared at professional society meetings and through the annual and midterm reports available online in NIMSS. Website updates are available in real-time to ensure the primary means of interacting between the NRSP and its stakeholders is current and useful. At professional society meetings, NRSP-9 members have given poster presentations, run informational booths, conducted symposia and workshops, and demonstrated the website utility to stakeholders. Reports available online succinctly detail the accomplishments and impacts of NRSP-9 on a yearly basis.

Past Successes

NRSP-9 is a novel forum for national collaboration and resource sharing was developed. As a result, NRSP-9 leveraged funds from the National Academies to create the only functional, nationally coordinated approach to support animal nutrition research, modeling, and feed data efforts. NRSP-9 is recognized as the national public forum and key source of expertise supporting the national animal nutrition research agenda. In evidence of this status, NRSP-9 was invited by the ILSI to participate in a workshop to identify and address topics related to plant composition. This workshop brought together experts in animal nutrition, plant breeding, worldwide. NRSP-9 also has been welcomed to work with ILSI's Crop Composition Database Working Group. The global impacts of NRSP-9 were further evidenced by requests from and interactions with representatives of organizations in China (i.e., Director of the Ministry of Agriculture Feed Industry Center in Beijing China and professor at China Agricultural University) and Europe (i.e., French National Institute for Agricultural Research, [INRA], the French Agricultural Research Center for International Development, [CIRAD], French Association for Animal Production [AFZ] and the Food and Agriculture Organization of the United Nations [FAO]) to invite collaboration and complementary efforts.

The 2023 NANP Summit took place at the National Academy of Science Building, in Washington DC on Wednesday, April 12, 2023. The stakeholders that were invited included: Animal commodity groups, Agriculture Committee staffers, USDA leadership, members of CFAR, AFIA, Agricultural Experiment Station leaders, NAS, FFAR, and Governors Council. The mission of the summit was to evaluate the use of animals to sustainably provide for healthy human diets. Speakers from across the country presented on livestock sustainability, challenges of world food security, alternate protein sources, impact of livestock on the environment and climate change, use of life cycles assessment and role of animals in future food systems. At this Summit we also hosted a Graduate Student Poster Competition. There were 16 abstracts submitted, from which 6 students were selected to receive a scholarship to attend the Summit and present their work in the form of a poster. Post Summit publications are in the process of being produced and will be widely circulated when finished.

A symposium aimed at bringing scientific communities from the American Society of Animal Science (ASAS) and the American Society of Nutrition (ASN) took place in 2018 to spur exchange of information on data acquisition and analytics for nutrition. This symposium, with attendance by 97 international participants, was extremely well received with the expressed desire for actual exposure, specific tools, and hands-on training in future symposia.

Modeling workshops have become a sought-after forum for exchanging of information and developing capabilities among students, university researchers, and industry professionals. Conducted yearly at the American Dairy Science Association (ADSA) annual meetings, these workshops have received tremendous interest. From 2019 to 2024 there have been 64 workshop and symposia presentations at national ASAS and ADSA (this number would also include the 9th Workshop on Modeling Nutrient Digestion and Utilization in Farm Animals; see Appendix 4). In conjunction with these presentations, 20 peer-reviewed articles were published. These articles have been cited 233 times and viewed in excess of 38,000 times (Appendix 3)

In addition to substantial evidence of growing national and international awareness of the NRSP-9 efforts, website data also clearly document stakeholder use of and interaction with website components. Key research support accomplishments over the current timeframe include the release of expanded searchable feed composition and animal performance databases; and posted summaries and links to modeling and statistics resources. These resources represent the four most popular pages on the website. During June of 2024, the collective feed composition database and associated resources received 1,357 pageviews (598 unique users) and the modeling database and associated resources received 417 pageviews (281 unique users), and the NASEM nutrient requirement model pages received 247 pageviews (196 unique users). Overall, the digital resources provide a robust system of integrated platform systems that permit NRSP-9 resources to be easily updated and available to global stakeholders while engaging them directly to enhance and improve committee efforts.

Future Additions and Activities

The current project expanded the focus to include aquaculture species, small ruminants, and horses. This resulted in a wider audience, including stakeholders interested specifically in these species. As we continue to expand our focus, new experts will be recruited to serve as committee members to appropriately represent the needs and interests of these new areas of focus. Two areas of consideration are individuals with capabilities in the "big data" area and individuals with a greater systems environmental impact understanding that incorporate animals into the whole production system (e.g., intensive vs extensive production systems, soil type and cropping decisions) to understand nutrient flow. International impact is already evident from website statistics and symposia/workshop attendance but that will be further enhanced by the presentation of our efforts at international meetings; a scheduled presentation at the 9th Workshop on Modelling Nutrient Digestion and Utilization in Farm Animals (attended by individuals from 17 countries) will broaden our exposure and will build new connections for collaboration in modeling research. In addition to broadening the audience, the next phase of NRSP-9 will focus heavily on soliciting stakeholder participation in the user feedback forum and increased attendance at meetings to gather feedback from stakeholders on valuable areas of focus for research support.

During the proposed future work of NRSP-9, performance measures that are in place will be monitored, the quantity and impact of publications will be measured, and stakeholder feedback will continually be assessed as components of an evaluation methodology. With the wider audience associated with inclusion of additional species, members plan to continue relying on website input and feedback, public meetings and workshops as communication methods; however, efforts will be made also to utilize additional, more interactive communication approaches such as webinars and social media activity.

Ingredient database and mathematical modeling projects will embrace AI where/when appropriate. This could include developing a chatbot for NRSP-9 that could use specific publications to train it and make it available to stakeholders. It is anticipated that the collaboration with NRCS will continue to develop. NRCS will become, in part, a repository NRCS evaluation tools and modeling resources.

The creation of the NANP nonprofit component (501(c)3) completed in 2023 will provide a platform for NANP to explore recruiting industry and non OTT MRF funding moving forward.

Organization/Governance

Literature Cited

Land Grant Participating States/Institutions

TX, MN, NE, AL, KY, PA, IL, VA, GA, CA, OK, NJ

Non Land Grant Participating States/Institutions

University of Idaho, University of Wisconsin - Milwaukee, USDA-ARS/Wisconsin

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:	2.71	0.20	0.10
302	0.1	0	0
302	0.1	0	0
302	0.05	0	0
302	0.05	0	0
302	0.01	0	0
302	0.3	0	0
302	0.1	0	0
302	0.1	0	0
302	0.1	0.1	0
302	0.1	0	0
302	0.03	0	0
302	0.03	0	0
302	0.03	0	0
302	0.03	0	0
302	0.05	0.1	0.1
302	0.05	0.1	0.1
302	0.1	0	0
302	0.1	0	0
302	0.1	0	0
302	0.1	0	0
302	0.1	0	0
302	0	0	0
302	1	0	0
305	0.05	0	0
307	0.05	0	0

Program/KA	Total FTE
Grand FTE Total:	1.2
302	0
302	0.03
302	0.02
302	0.02
305	0.33
307	0.33
302	0.02

Budgets

MRF Funding 2025

Description	Dollars	FTE
Salaries	89000.00	1.00
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	212000.00	0.00
Totals	301000	1

Comments

Other Funding 2025

Description	Dollars	FTE
Salaries	682250.00	8.95
Fringe Benefits	136450.00	0.00
Wages	0.00	0.00
Travel	43000.00	0.00
Supplies	0.00	0.00
Maintenance	0.00	0.00
Equipment / Capital Improvement	0.00	0.00
Other	6506675.00	0.00
Totals	7368375	8.95
Comments		

MRF Funding 2026

Description	Dollars	FTE
Salaries	89000.00	1.00
Fringe Benefits	0.00	0.00
Wages	0.00	0.00
Travel	18000.00	0.00
Supplies	0.00	0.00
Maintenance	0.00	0.00
Equipment / Capital Improvement	0.00	0.00
Other	262000.00	0.00
Totals	369000	1

Comments

Other Funding 2026

Description	Dollars	FTE
Salaries	695895.00	8.95
Fringe Benefits	139179.00	0.00
Wages	0.00	0.00
Travel	43000.00	0.00
Supplies	0.00	0.00
Maintenance	0.00	0.00
Equipment / Capital Improvement	0.00	0.00
Other	6510769.00	0.00
Totals	7388843	8.95
Comments		

MRF Funding 2027

Description	Dollars	FTE
Salaries	89000.00	1.00
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	212000.00	0.00
Totals	301000	1

Comments

Other Funding 2027

Description	Dollars	FTE
Salaries	709813.00	8.95
Fringe Benefits	141963.00	0.00
Wages	0.00	0.00
Travel	43000.00	0.00
Supplies	0.00	0.00
Maintenance	0.00	0.00
Equipment / Capital Improvement	0.00	0.00
Other	6514944.00	0.00
Totals	7409720	8.95
Comments		

MRF Funding 2028

Description	Dollars	FTE
Salaries	89000.00	1.00
Fringe Benefits	0.00	0.00
Wages	0.00	0.00
Travel	18000.00	0.00
Supplies	0.00	0.00
Maintenance	0.00	0.00
Equipment / Capital Improvement	0.00	0.00
Other	212000.00	0.00
Totals	319000	1

Comments

Other Funding 2028

Description	Dollars	FTE
Salaries	724009.00	8.95
Fringe Benefits	144802.00	0.00
Wages	0.00	0.00
Travel	43000.00	0.00
Supplies	0.00	0.00
Maintenance	0.00	0.00
Equipment / Capital Improvement	0.00	0.00
Other	6519203.00	0.00
Totals	7431014	8.95
Comments		

MRF Funding 2029

Description	Dollars	FTE
Salaries	89000.00	1.00
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	212000.00	0.00
Totals	301000	1

Comments

Other Funding 2029

Description	Dollars	FTE
Salaries	738489.00	8.95
Fringe Benefits	147698.00	0.00
Wages	0.00	0.00
Travel	43000.00	0.00
Supplies	0.00	0.00
Maintenance	0.00	0.00
Equipment / Capital Improvement	0.00	0.00
Other	6523547.00	0.00
Totals	7452734	8.95
Comments		

Supplementary Table 1. Requested NANP direct funds budget

Description^a	FY2026	FY2027	FY2028	FY2029	FY2030	5 Yr Totals
Salaries ^b						
Modeling Coordinator (post doc)	\$77,000	\$77,000	\$77,000	\$77,000	\$77,000	\$385,000
Administrative Assistant (25%)	\$12,000	\$12,000	\$12,000	\$12,000	\$12,000	\$60,000
Committee Chair Support	\$30,000	\$30,000	\$30,000	\$30,000	\$30,000	\$150,000
Travel		\$18,000		\$18,000		\$36,000
Summit		\$50,000				\$50,000
Supplies ^c	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	\$5,000
Website maintenance and data management	\$120,000	\$120,000	\$120,000	\$120,000	\$120,000	\$600,000
Workshops and Symposiums	\$20,000	\$20,000	\$20,000	\$20,000	\$20,000	\$100,000
Publications	\$4,000	\$4,000	\$4,000	\$4,000	\$4,000	\$20,000
Social Media	\$27,000	\$27,000	\$27,000	\$27,000	\$27,000	\$135,000
National Academies Science, Engineering, and Medicine	\$10,000	\$10,000	\$10,000	\$10,000	\$10,000	\$50,000
Total	\$301,000	\$369,000	\$301,000	\$319,000	\$301,000	\$1,591,000

^aDollars provided will be split among the Coordinating Committee, Feed Composition Committee, Modeling Committee, and the Climate Smart Feed Management Committee. Fringe benefits are to be provided by hosting institution.

^bSalaries are for professional and technical support staff for coordinating meetings, developing and distributing materials. Salaries of members and collaborators are contributed by the participating institutions.

^cSupplies include computer supplies and software for maintaining databases and computer information servers, shipping costs, publication costs, postage, and communications activities.

Supplementary Table 2. Total projected NANP budget including direct and leveraged funds

Description	FY2026	FY2027	FY2028	FY2029	FY2030	5 Yr Totals
Requested NANP direct funds (from Table 1):	\$301,000	\$369,000	\$301,000	\$319,000	\$301,000	\$1,591,000
Anticipated leveraged in kind support (from Table 3):	\$7,368,375	\$7,388,843	\$7,409,719	\$7,431,014	\$7,452,734	\$37,050,685
Anticipated leveraged grant dollars (from Table 4):	\$1,325,000	\$1,325,000	\$11,105,000	\$1,600,000	\$1,450,000	\$16,805,000
Total projected NANP budget from all sources:	\$8,994,375	\$9,082,843	\$18,815,719	\$9,350,014	\$9,203,734	\$55,446,685

Supplementary Table 3. Leverage in-kind; Institutional salary support, indirect costs, other institutional costs, value of feed analyses, travel, and publications costs.

Description	FY2026	FY2027	FY2028	FY2029	FY2030	5 Yr Totals
Salaries ^a						
Committee members (SY)	\$473,000	\$482,460	\$492,109	\$501,951	\$511,990	\$2,461,511
Technical support (TY)	\$112,500	\$114,750	\$117,045	\$119,386	\$121,774	\$585,455
Administrative support	\$96,750	\$98,685	\$100,659	\$102,672	\$104,725	\$503,491
Fringe benefits	\$136,450	\$139,179	\$141,963	\$144,802	\$147,698	\$710,091
Institutional indirect cost	\$204,675	\$208,769	\$212,944	\$217,203	\$221,547	\$1,065,137
Institutional support ^b						
Coordinating Animal Nutrition Committee	\$73,000	\$73,000	\$73,000	\$73,000	\$73,000	\$365,000
Feed and Ingredient Composition Committee	\$73,000	\$73,000	\$73,000	\$73,000	\$73,000	\$365,000
Modeling Committee	\$73,000	\$73,000	\$73,000	\$73,000	\$73,000	\$365,000
Climate Smart Feed Management Committee	\$73,000	\$73,000	\$73,000	\$73,000	\$73,000	\$365,000
Feed analysis and ingredient composition ^c	\$6,000,000	\$6,000,000	\$6,000,000	\$6,000,000	\$6,000,000	\$30,000,000
Travel ^d	\$43,000	\$43,000	\$43,000	\$43,000	\$43,000	\$215,000
Publications ^e	\$10,000	\$10,000	\$10,000	\$10,000	\$10,000	\$50,000
Total	\$7,368,375	\$7,388,843	\$7,409,719	\$7,431,014	\$7,452,734	\$37,050,685

^aInstitutional salary support contributions calculated at 0.10 FTE per committee member (43 committee members) with an average salary of \$110,000/year. Technical support is calculated as 0.10 FTE for 25 technicians supporting scientists on the project and an average technical salary of \$45,000. Administrative support is calculated as 0.05 (FTE) per year for 43 committee members with an average administrative salary of \$45,000/ year. Institutional indirect costs were calculated as 25% of salaries + fringes. Fringe benefits were calculated as 20% of salary. A 2% cost of living adjustment has been included across years.

^bIn-kind institutional support includes support from public institutions and private industry, and includes but is not limited to: products, supplies, and equipment (furniture, computers, office equipment), professional and employee expertise (graphic arts/design, writing/advertising/promotion/marketing, legal assistance, business and financial advice, strategic planning) and other non-specified in-kind support.

^cEstimated as the value of an additional 200,000 feed analyses added to the data base per year at \$30/sample.

^dTravel in kind support was calculated as 43 scientists as \$1000/year for each scientist. Fund sources will vary but include institutional and industry contributions.

^ePublication in kind support is consists of anticipated industry and professional society support for publications.

Supplementary Table 4. Leverage, Anticipated grant support.

Description	FY2026	FY2027	FY2028	FY2029	FY2030	5 Yr Totals
Grant description						
Postdoctoral grants ^a	\$0	\$0	\$125,000	\$250,000	\$125,000	\$500,000
Conference grants and symposium leveraging ^b	\$50,000	\$50,000	\$75,000	\$75,000	\$50,000	\$300,000
Climate Smart NRCS support	\$200,000	\$200,000	\$200,000	\$200,000	\$200,000	\$1,000,000
Research Grants ^c	\$1,075,000	\$1,075,000	\$10,705,000	\$1,075,000	\$1,075,000	\$15,005,000
Total	\$1,325,000	\$1,325,000	\$11,105,000	\$1,600,000	\$1,450,000	\$16,805,000

^bPostdoctorals hired onto the project will be encouraged to write postdoctoral fellowship grants to two years of salary funding, travel, publication, and a small amount of operating. This effort will accomplish professional development for the postdoctoral fellow, fund leveraging for the grant, and labor pool multiplication. When postdocs are funded by grants, NANP funds will be used to hire an additional postdoc. Consequently, we plan to leverage 1 postdoc positions into 3.

^cAs symposiums at conferences are a key component of NANP activities, funds will be actively recruited to support these activities. The \$50,000 per year represents \$30,000 in funded grants annually and another \$20,000 in direct support from co-sponsoring professional societies and professional organizations. the additional \$25,000 in FY 28 is from anticipated funding support for the planned summit.

^dThese funds represent extramural grant funds secured by members of the NANP team that have emphasis into NANP focus areas. These are funds that support research into key NANP areas and are led by NANP team members. There are currently 43 NANP scientists on the team and the leveraged dollar estimate is likely low. We estimated \$25,000/scientist per year. Accurate records should be kept on this type of leveraging and reported annually.

Supplementary Table 5. Multiple mechanisms and sources of funding leveraged by NRSP-9.

NRSP-9's Contribution	Value	Leverage	Partners ^a
Feed composition information on 2,760,000 samples	2,760,000 samples x \$30/sample = \$82,800,000	Information made publicly accessible represents over \$82 million in analytical costs if analyses were conducted and paid for by individuals.	Industry (private, for-profit) NASEM (private, non-profit)
USDA Beltsville data recovered and preserved	\$6,240,000 ^b	Securing Beltsville chamber data represents the preservation of results from 150,000 research hours.	Agricultural Research Service (government) NASEM (private, non-profit)
Research support to national poultry, swine and dairy nutrition efforts	\$900,000	Research support to the NASEM efforts helped leverage \$900,000 in sponsor support to establish nutrient requirements for multiple species for use by researchers.	Various industries and professional societies. NASEM (private, non-profit)
Research support for Climate Smart activities	\$1,500,000	Research support in the area of climate smart feed management.	NRCS Industry (private, for profit).
Professional society workshops and symposia	\$100,691	Multiple funded proposals and activities for conference support 2019 to 2024	NIFA/USDA support programs Professional Society support
Total leveraged support:			

^aPartners contributed the funds or nominal value listed in the Value column.

^bEstimate based on average wage of \$40/h, 25 years of employing 3 full-time researchers at Beltsville; costs of running experiments were not included.

Supplementary Table 6. Publications associated directly with the NRSP-9, National Animal Nutrition Program*

Year	Peer-reviewed print publications	Peer-reviewed on-line video publications	Proceedings Abstracts	On-line guides, white papers
2015	1		7	3
2016	4		6	1
2017	2		6	
2018		1	15	1
2019	3		20	
2020	4			
2021	5			
2022	3			
2023	4			
Total	26	1	54	5

* The listing does not include publications of individual committee members related to NRSP-9 objectives that were funded through their institutions.

(<https://animalnutrition.org/peer-reviewed-papers>)

Supplementary Table 7. Longitudinal website user metrics over 1-month period (June 1-30) in 2019 vs 2024

Metric	Traffic over 1-month period			Explanation
	March 2019	June 2024	% Change	
New users (unique)	473	1,355	+186.5	Adding unique users at a significant rate
New user countries	58	95	+63.8	Adding new users from many more countries
New U.S.-based users, % of total new users	51	35	-31.4	Greater visibility of NANP resources within the global nutrition community.
Returning users	104	146	+40.4	More users return to the website repeatedly
Engaged sessions	789	1,318	+67.0	Users are returning to the website for twice as many sessions
Pageviews	2,471	4,813	+94.8	Users are viewing more content each time they return to the website
Pageviews/session	3.13	3.65	+16.6	Decreased rate suggests users are better able to find the content they're looking by visiting fewer pages (i.e., website is easier to navigate)

Cumulative Pageviews

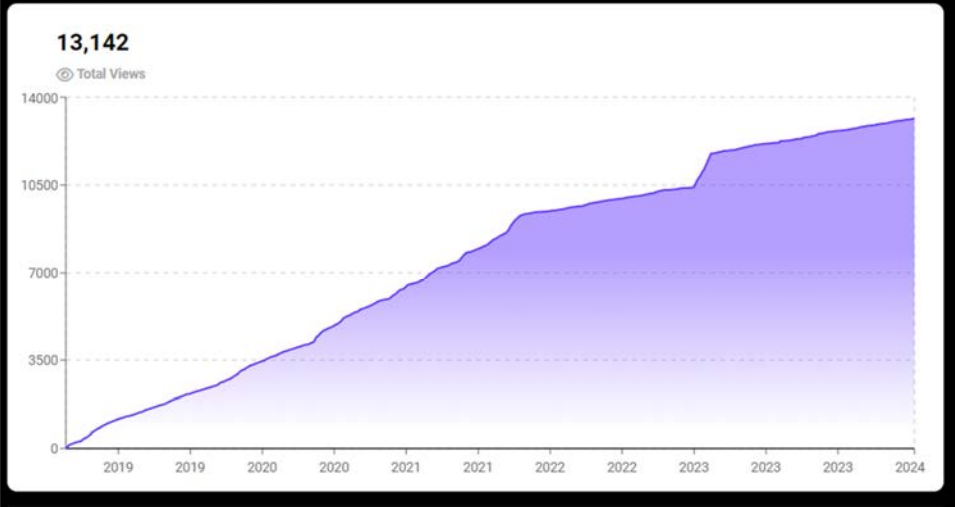


Figure 1. Accelerating impact of the peer-reviewed on-line video publication.

Website Traffic by Country



Figure 2. Comparative breakdown for 2018 to 2021 (3 yr) and 2023-2024 (1 yr) of website traffic by country.

Appendix 1: Members of the National Research Support Program-9 (NRSP-9)

Coordinating Animal Nutrition Committee:

Phil Miller (Chair)

- University of Nebraska
- Swine

Merlin Lindemann (Past Chair)

- University of Kentucky
- Swine

Gary Cromwell (Chair emeritus)

- University of Kentucky
- Swine

Don Beitz

- Iowa State University
- Dairy, Metabolism

Joel Caton

- North Dakota State University
- Beef, Small Ruminant

Delbert Gatlin

- Texas A&M University
- Aquaculture

Arthur Goetsch

- Langston University
- Small Ruminant

Ryan Dilger (Representing the Feed Composition Committee)

- University of Illinois
- Swine, Poultry

Luis Tedeschi (Representing the Modeling Committee)

- Texas A&M University
- Beef

Nancy Irlbeck

- Washington State University
- Horse, Small Ruminant

Heidi Rossow

- University of California-Davis
- Dairy

Brian Small

- University of Idaho
- Aquaculture

Carey Williams

- Rutgers State University
- Equine

Feed Composition Committee:

Ryan Dilger (Chair)

- University of Illinois
- Swine, Poultry

William Dozier

- Auburn University
- Poultry

Mark Edwards

- Cal-Poly – San Luis Obispo
- Equine, Small Ruminant

Tara Felix

- Pennsylvania State University
- Beef

Andrew Foote

- Oklahoma State University
- Beef

Alexander Hristov

- Pennsylvania State University
- Dairy

Brooke Humphrey

- Phibro Animal Health
- Swine, Poultry

Woo Kyun Kim

- University of Georgia
- Poultry

Fredric Owens

- Oklahoma State University
- Beef

Brian Small

- University of Idaho
- Aquaculture

Sandra Solaiman

- Tuskegee University
- Small Ruminant

Modeling Committee:

Luis Tedeschi (Chair)

- Texas A&M University
- Beef

Dominique Bureau

- University of Guelph
- Aquaculture

Todd Callaway

- University of Georgia
- Micro

Peter Ferket

- North Carolina State University
- Poultry

Arthur Goetsch

- Langston University
- Small Ruminant

Tim Hackmann

- University of Florida
- Rumen Microbiology

Mark Hanigan

- Virginia Tech University
- Dairy

Hector Menendez

- South Dakota State University
- Beef

Edgar Oviedo-Rondon

- North Carolina State University
- Poultry

Emiliano Raffrenato

- RUM&N Consulting
- Dairy, Beef, Industry

Aline Remus

- Agriculture and AgriFood Canada
- Swine

Heidi Rossow

- University of California-Davis
- Dairy

Mike VandeHaar

- Michigan State University
- Dairy

Robin White

- Virginia Tech
- Beef, Dairy

Sarah White-Springer

- Texas A&M University
- Horse

Climate Smart Feed Management Committee:

Luis Tedeschi (Chair)

- Texas A&M University
- Ruminant Nutrition

Matthew R. Beck

- USDA-ARS Livestock Nutrient Management Research
- Ruminant Nutritionist

Ellen Dierenfeld

- World Wildlife Fund
- Sustainable Feed Innovations

Mary Drewnoski

- University of Nebraska
- Beef Systems Specialist

Andrew Foote

- Oklahoma State University
- Ruminant Nutrition

Elizabeth French

- USDA-ARS Dairy Forage Research Center
- Dairy Nutrition, Precision Feeding

Karun Kaniyamattam

- Texas A&M University
- Livestock Data Analytics, Artificial Intelligence

Jim MacDonald

- University of Nebraska
- Ruminant Nutrition, Beef Systems

Hector Menendez

- South Dakota State University
- Ruminant Grazing Systems

Heidi Rossow

- University of California-Davis
- Ruminant Nutrition Management

Jerry Shurson

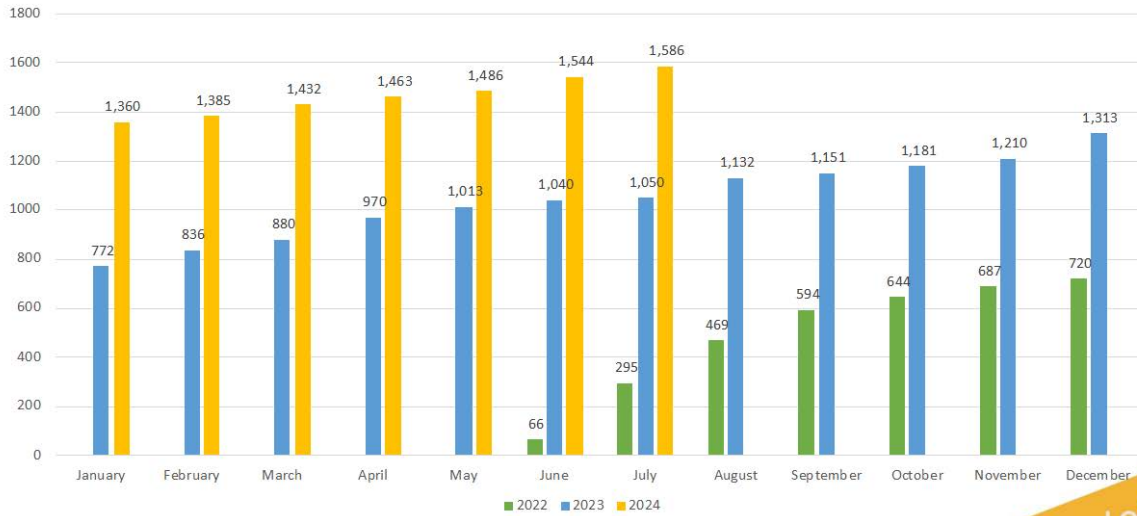
- University of Minnesota
- Swine Nutrition

Elias Uddin

- University of Connecticut
- Life Cycle Assessment

Appendix 2. Impact of the NRSP-9 social media efforts. Values represent total individuals among all social media platforms.

Audience Growth June 2022 – July 2024



Appendix 3 CITATIONS

Since 2019, there are 20 peer-reviewed papers that were cited 233 times. We used the metrics from the Journal and the Web of Science Citation tool.

Reference	Citations/Views and Notes
2023	
Brennan, J., H. M. Menendez, III, K. Ehlert, and L. O. Tedeschi. 2023. ASAS-NANP symposium: mathematical modeling in animal nutrition—Making sense of big data and machine learning: how open-source code can advance training of animal scientists. <i>J. Anim. Sci.</i> 101:skad317. doi: 10.1093/jas/skad317	3 / 1,267
Kaniyamattam, K., and L. O. Tedeschi. 2023. ASAS-NANP symposium: mathematical modeling in animal nutrition: Agent-based modeling for livestock systems: the mechanics of development and application. <i>J. Anim. Sci.</i> 101:skad321. doi: 10.1093/jas/skad321	1 / 890
Muñoz-Tamayo, R., and L. O. Tedeschi. 2023. ASAS-NANP symposium: Mathematical modeling in animal nutrition: the power of identifiability analysis for dynamic modeling in animal science - a practitioner approach. <i>J. Anim. Sci.</i> 101:skad320. doi: 10.1093/jas/skad320	3 / 827
Tedeschi, L. O., H. M. Menendez, III, and A. Remus. 2023. ASAS-NANP SYMPOSIUM: Mathematical modeling in animal nutrition: Training the future generation in data and predictive analytics for sustainable development. A summary of the 2021 and 2022 symposia. <i>J. Anim. Sci.</i> 101:skad318. doi: 10.1093/jas/skad318	0 / 1,313
2022	
Jacobs, M., A. Remus, C. Gaillard, H. M. Menendez, III, L. O. Tedeschi, S. Neethirajan, and J. L. Ellis. 2022. ASAS-NANP SYMPOSIUM: MATHEMATICAL MODELING IN ANIMAL NUTRITION: Limitations and potential next steps for modeling and modelers in the animal sciences. <i>J. Anim. Sci.</i> 100 (6):1-15. doi: 10.1093/jas/skac132	10 / 831 80% of its citations have been received in the past two years, which is higher than you might expect, suggesting that it is currently receiving a lot of interest.
Menendez, H. M., III, J. R. Brennan, C. Gaillard, K. Ehlert, J. Quintana, S. Neethirajan, A. Remus, M. Jacobs, I. A. M. A. Teixeira, B. L. Turner, et al. 2022. ASAS-NANP SYMPOSIUM: MATHEMATICAL MODELING IN ANIMAL NUTRITION: Opportunities and challenges of confined and extensive precision livestock production. <i>J. Anim. Sci.</i> 100 (6):1-19. doi: 10.1093/jas/skac160	15 / 4,125 93% of its citations have been received in the past two years, which is higher than you might expect, suggesting that it is currently receiving a lot of interest.

	Compared to other publications in the same field, this publication is extremely highly cited and has received approximately 9.9 times more citations than average.
Tedeschi, L. O. 2022. ASAS-NANP SYMPOSIUM: MATHEMATICAL MODELING IN ANIMAL NUTRITION: The progression of data analytics and artificial intelligence in support of sustainable development in animal science. J. Anim. Sci. 100 (6):1-11. doi: 10.1093/jas/skac111	15 / 2,853 86% of its citations have been received in the past two years, which is higher than you might expect, suggesting that it is currently receiving a lot of interest.
2021	
Gerrits, W., M. Schop, S. de Vries, and J. Dijkstra. 2021. ASAS-NANP symposium: digestion kinetics in pigs: The next step in feed evaluation and a ready-to-use modeling exercise. J. Anim. Sci. 99 (2):1-8. doi: 10.1093/jas/skab020	14 54% of its citations have been received in the past two years, which is higher than you might expect, suggesting that it is currently receiving a lot of interest.
Morota, G., H. Cheng, D. Cook, and E. Tanaka. 2021. ASAS-NANP SYMPOSIUM: prospects for interactive and dynamic graphics in the era of data-rich animal science. J. Anim. Sci. 99 (2):1-17. doi: 10.1093/jas/skaa402	10 / 2,391 50% of its citations have been received in the past two years.
Stephens, E. C. 2021. ASAS-NANP SYMPOSIUM: Review of systems thinking concepts and their potential value in animal science research J. Anim. Sci. 99 (2):1-7. doi: 10.1093/jas/skab021	6 / 869 33% of its citations have been received in the past two years.
Tedeschi, L. O., D. P. Bureau, P. R. Ferket, and N. L. Trottier. 2021. ASAS-NANP SYMPOSIUM: Mathematical modeling in animal nutrition: training the future generation in data and predictive analytics for sustainable development. A Summary. J. Anim. Sci. 99 (2):1-3. doi: 10.1093/jas/skab023	1 / 1,695
Wang, Z., S. Shadpour, E. Chan, V. Rotondo, K. Wood, and D. Tulpan. 2021. ASAS-NANP SYMPOSIUM: Applications of machine learning for livestock body weight prediction from digital images. J. Anim. Sci. 99 (2):1-15. doi: 10.1093/jas/skab022	48 / 7,336 68% of its citations have been received in the past two years, which is higher than you might expect, suggesting that it is currently receiving a lot of interest. Compared to other publications in the same field, this publication is extremely

	highly cited and has received approximately 20 times more citations than average.
2020	
Tran, H., A. Schlageter-Tello, A. Caprez, P. S. Miller M. B. Hall, W. P. Weiss, and P. J. Kononoff. 2020. Development of feed composition tables using a statistical screening procedure. <i>J. Dairy Sci.</i> 103:P3786-3803. doi:10.3168/jds.2019-16702	13
Schlageter-Tello, A., G. C. Fahey, T. Freel, L. Koutsos, P. S. Miller, and W. P. Weiss. 2020. ASAS-NANP Symposium: Ruminant/Nonruminant Feed Composition: Challenges and opportunities associated with creating large feed ingredient composition tables. <i>J. Anim. Sci.</i> 98. doi:10.1093/jas/skaa240	1 / 2,718
Menendez III, H. M. and L. O. Tedeschi. 2020. The characterization of the cow-calf, stocker and feedlot cattle industry water footprint to assess the impact of livestock water use sustainability. <i>J. Agric. Sci.</i> doi:10.1017/S0021859620000672	13 / 1,530
Mark D. Hanigan and Veridiana L. Daley. 2020. Use of Mechanistic Nutrition Models to Identify Sustainable Food Animal Production. <i>Annu. Rev. Anim. Biosci.</i> 8:355-376. doi:10.1146/annurev-animal-021419-083913	5
2019	
Daley, V. L., L. E. Armentano, P. J. Kononoff, and M. D. Hanigan. 2019. Modeling fatty acids for dairy cattle: models to predict total fatty acid concentration and fatty acid digestion of feedstuffs. <i>J. Dairy Sci.</i> 103:6982-6999. doi:10.3168/jds.2019-17407	11
C.F Nicholson, A.R.P. Simões, P.A. LaPierre, M.E. Van Amburgh. 2019. ASN-ASAS Symposium: Future of Data Analytics in Nutrition: Modeling complex problems with system dynamics: applications in animal agriculture. <i>J. Anim. Sci.</i> 97:1903–1920. doi:10.1093/jas/skz105	8 / 2,208 62% of its citations have been received in the past two years.
L.O. Tedeschi. ASN-ASAS Symposium: Future of Data Analytics in Nutrition: Mathematical modeling in ruminant nutrition: approaches and paradigms, extant models, and thoughts for upcoming predictive analytics. <i>J. Anim. Sci.</i> 7:1921–1944. doi:10.1093/jas/skz092	56 / 7,163 42% of its citations have been received in the past two years, which is higher than you might expect, suggesting that it is currently receiving a lot of interest.
Total	233 citations

Appendix 4 WORKSHOPS & SYMPOSIA

There were 46 invited speakers, representing national and international universities, industry, and government.

Year	Meeting	Speaker	Institute
2024	ASAS-CSAS-WSASAS Annual Meeting, Calgary, Canada		
1	Introduction	L. O. Tedeschi	Texas A&M University
2	Precision livestock farming: Harnessing artificial intelligence for animal management	I. C. F. S. Condotta	University of Illinois at Urbana-Champaign
3	Combining dynamic models with deep learning through time series analysis	H. M. Rekabdarkolae	South Dakota State University
4	Applying system dynamics to develop “flight simulators” for sustainable animal production	H. M. Menendez III	South Dakota State University
5	Environmental evaluation of feeding strategies with agent-based modeling and life cycle assessment: from theory to practice	F. Garcia-Launay	INRAE UMR PEGASE
6	Introduction to developing Python computational pipelines for predictive machine learning modeling of livestock data	D. Tulpan	University of Guelph
2023	ASAS-CSAS-WSASAS Annual Meeting & Trade Show, Albuquerque, NM		
1	Introduction	L. O. Tedeschi	Texas A&M University
2	Advantages, difficulties, and pitfalls of processing and combining different types of real-time data	T. Brown-Brandl	University of Nebraska-Lincoln
3	Satellite-based decision support tools to assist grazing cattle production	M. H. M. R. Fernandes	São Paulo State University
4	Overview of poultry modeling evolution	E. O. Oviedo-Rondon	North Carolina State University
5	Building an Agent-Based Model in AnyLogic	W. McDonald	University of Saskatchewan
6	The role of system dynamics modeling for sustainable livestock production	A. S. Atzori	University of Sassari
7	Building digital twins for precision livestock farming: Data analytics and big data challenges	J. Tao	Texas A&M University
2023	NANP Nutrition Models Workshop at ADSA Annual Meeting, Ottawa, Canada		
1	Model validation	J. Chen	Virginia Tech
2	Building a nutrient requirement model	M. D. Hanigan	Virginia Tech
3	Meta-analysis	R. J. Tempelman	Michigan State University
2022	ASAS-CSAS Annual Meeting & Trade Show, Oklahoma City, OK		
1	Introduction	L. O. Tedeschi	Texas A&M University
2	The Power of Theoretical and Practical Identifiability Analysis for Modeling (micro-) Biological Processes	R. Muñoz-Tamayo	INRAE-AgroParisTech, University Paris-Saclay
3	Automation, Machine Learning and Computer Vision as Decision Support	S. McClain	SAS Institute

4	Building Models for Animal Production and Management with System Dynamics Modeling: A Basic Introduction to System Dynamics Modeling	B. L. Turner	Texas A&M University-Kingsville
5	Hands-on: Agent-Based Modeling in Agriculture	K. Kaniyamattam	Texas A&M University
6	Hands-on: Making Sense of Big Data, Machine Learning, and Modeling	J. Brennan	South Dakota State University
2021	ASAS-CSAS-WSASAS Annual Meeting & Trade Show, Louisville, KY		
1	Introduction	L. O. Tedeschi	Texas A&M University
2	Opportunities and Limitations of Modeling and Data Analytics for Precision Livestock Farming	A. Remus	Agriculture and Agri-Food Canada
3	Application of Precision Sensor Technologies, Real-time Data Analytics, and Dynamic Models on Extensive Western Rangeland Grazing Systems	H. M. Menendez III	South Dakota State University
4	Mapping Resilience Indicators and Measuring Emotions of Farm Animals Using Sensor Data	S. R. Neethirajan	Wageningen University & Research
5	The Adoption of AI in the Core Scientific Cycle of Feed Research	M. Jacobs	Trouw Nutrition
6	Integrating Mechanistic Models with AI for Precision Feeding of Sows	C. Gaillard	PEGASE, INRAE, Institut Agro
7	EnROADS: Overview of Climate Change Modeling	C. Jones	Climate Interactive
8	Statistical Graphics and Interactive Visualization in Animal Science	G. Morota	Virginia Polytechnic Institute and State University
9	A Brief Overview, Comparison and Practical Applications of Machine Learning Models	D. Tulpan	University of Guelph
2021	NANP Nutrition Models Workshop at ADSA Annual Meeting (VIRTUAL)		
1	Tutorial on R	T. J. Hackmann	University of California, Davis
2	Parameter estimation: Lecture and exercises	K. F. Reed	Cornell University
3	Cross-validation and bootstrapping: Lecture and exercises	R. Appuhamy	Iowa State University
4	Automated model selection: Lecture and exercises	V. L. Daley	Land O'Lakes, Davis
5	Molly and other dynamic models: Lecture and exercises	H. A. Rossow	University of California, Davis
2020	ASAS-CSAS-WSASAS Annual Meeting & Trade Show (VIRTUAL)		
1	Introduction	L. O. Tedeschi	Texas A&M University
2	Building models using system dynamics methodology: applications to animal science	E. C. Stephens	Agriculture and Agri-Food Canada
3	Modelling digestion kinetics in pigs	W. Gerrits	Wageningen University & Research
4	A brief overview, comparison and practical applications of machine learning models (theoretical background, demos, instructions + hands-on examples)	D. Tulpan	University of Guelph

5	Statistical graphics and interactive visualization in animal science	G. Morota	Virginia Polytechnic Institute and State University
2020	NANP Nutrition Models Workshop at ADSA Annual Meeting (VIRTUAL)		
1	Tutorial on R	V. L. Daley	Land O'Lakes
2	Model construction	T. J. Hackmann	University of California, Davis
3	Evaluating model predictions	H. van Lingen	University of California, Davis
4	Meta-analysis	V. L. Daley	Land O'Lakes, Davis
5	Building a nutrient requirement model	M. D. Hanigan	Virginia Tech
2019	Satellite workshop: 9th Workshop on Modelling Nutrient Digestion and Utilization in Farm Animals (MODNUT)		
1	Linear Models and Meta-Regression (Theoretical background including instructions for practical, followed by hands-on examples)	K. Reed	Cornell University
2	Mechanistic Models (Theoretical background including instructions for practical, followed by hands-on examples)	M. D. Hanigan	Virginia Tech
3	Install R and RStudio - NANP and Virginia Tech	V. L. Daley and Members of Dr. Hanigan's Lab (Xinbei, Alvaro, Leticia, Jacquelyn, Alexis)	Virginia Tech
2019	ASAS-CSAS Annual Meeting & Trade Show, Austin, TX		
1	ASAS-NANP Symposium Introduction		
2	Introduction to mathematical models	M. D. Hanigan	Virginia Tech, Virginia, USA
3	Building Models for Animal Production and Management with System Dynamics Modeling	B. L. Turner	Texas A&M University-Kingsville
4	Introduction to R and R Scripting	R. R. White	Virginia Tech
5	Assessing the predictive adequacy of simple and complex mathematical models	L. O. Tedeschi	Texas A&M University
6	Overview and Case Studies of Cutting Edge Artificial Intelligence Techniques	H. M. Menendez III	Texas A&M University
2019	NANP Nutrition Models Workshop at ADSA Annual Meeting, Cincinnati, OH		
1	Welcoming remarks	J. McNamara	Washington State University
2	Tutorial on R	T. J. Hackmann	University of California, Davis
3	Estimation of Parameter Values: lecture	M. D. Hanigan	Virginia Tech
4	Lesson 1: Estimation of Parameter Values: exercises	M. D. Hanigan	Virginia Tech
5	Bootstrap and Cross-Validation: lecture	R. Appuhamy	Iowa State University Ames
6	Lesson 2: Bootstrap and Cross-Validation: exercises	R. Appuhamy	Iowa State University Ames

7	Automated Model Selection: lecture	V. L. Daley	University of Kentucky
8	Lesson 3: Automated Model Selection: exercises	V. L. Daley	University of Kentucky
9	Molly and other dynamic models: lecture	H. A. Rossow	University of California, Davis
10	Lesson 4: Molly and other dynamic models: exercises	H. A. Rossow	University of California, Davis
2018	ASAS-CSAS Annual Meeting & Trade Show, Vancouver, Canada		
1	Relevance and Collaboration with the National Research Council	M. D. Lindemann	University of Kentucky, National Animal Nutrition Program (NANP)
2	Food and Agriculture Cyberinformatics and Tools	C. K. Baer	National Institute of Food and Agriculture US Department of Agriculture
3	The evolution of mathematical models for animal nutrition: what to expect next?	L. O. Tedeschi	Texas A&M University
4	Combining simplicity and complexity: creating user-applications from mechanistic nutritional models	J. van Milgen	INRA
5	Modeling the impact of climate change on whole farm systems	A. D. Moore	Digiscape Future Science Platform, CSIRO
6	Decision support for foot-and-mouth disease emergency preparedness: the use of computer modeling and visual analytical tools to evaluate control strategies	L. K. Holmstrom	USDA-NAHMS
7	Modeling complex problems with system dynamics: Applications in Animal Agriculture	C. Nicholson	Cornell University
8	Innovative ways to see data	J. C. Hart	University of Illinois at Urbana-Champaign
2018	NANP Nutrition Models Workshop at ADSA Annual Meeting, Knoxville, TN		
1	Introduction and model construction (Part I and II)	T. J. Hackmann, M. D. Hanigan, V. L. Daley	University of California, Davis, Virginia Tech
2	Model evaluation (Part I and II)	E. Kebreab	University of California, Davis
3	Meta-analysis (Part I)	R. R. White	Virginia Tech
4	Opportunities for federal funding of modeling research	S. I. Smith	USDA
2017	NANP Nutrition Models Workshop at ADSA Annual Meeting, Pittsburgh, PA		
1	Welcoming remarks		
2	Purposes and types of models	M. D. Hanigan	Virginia Tech
3	Dynamic deterministic models	T. J. Hackmann	University of California, Davis
4	Estimation of parameter values in nutrition models	L. E. Moraes	University of California, Davis
5	Model evaluation	E. Kebreab	University of California, Davis

6	Example models for ruminant digestion and metabolism	H. A. Rossow	University of California, Davis
7	Meta-regression analysis of animal nutrition literature	R. R. White	Virginia Tech

There were 46 invited speakers, representing national and international universities, industry, and government.

NRSP-9 Renewal – addressing reviewers’ comments

First the NRSP-9 Coordinating Committee is grateful for the comments provided by reviewers. The Committee appreciates the recognition of the NRSP-9 over the past 15 years.

The points raised by the reviewers can be generally categorized as follows:

1. Elaborate the future role of the nonprofit component of NANP and how this might dovetail with other financial collaborations with industry and government entities.
2. Further highlight the contributions of the NRSP-9 to the development of NASEM Nutrient Requirement Series projects and publications. This could include developing a closer relationship with BANR.
3. Describe how NRSP-9 can leverage objectives and activities to help provide insight in to how livestock genetic improvement affects nutrient requirements and nutrient use and the environment.

Below are comments/revisions based on Reviewers’ 1-3 comments:

Reviewer 1

Yet much more can be done with some expansions of focus on 1) integrating with genetic improvement of animals (as is addressed by the authors but needs to be strengthened and 2) developing a more defined, focused and funded cooperation with the National Research Council, The Board on Agriculture and Natural Resources of The National Academies. Detailed review points are below, followed by suggestions for revisions.

The above points do come out in the specific comments. It is highlighted several places in the “Prerequisite Criteria” the strong linkage of the NRSP-9 charge and support of the NASEM Nutrient Requirement Publication. The first three objectives for the new proposal are directly linked to augmenting the NANP nutrient database(s) and requirement models. We believe that this has been highlighted in numerous locations in the renewal.

A major impact that is not sufficiently discussed is the fact that this group is responsible for the success of the NRC Nutrient Requirements of Animals program, the major goal of creating this NRSP in the first place.

The NRSP-9 project group appreciates the reviewer’s comments here. Our role with NASEM has been close and will continue in the future. Historically NRSP-9 has not worked directly with BANR, but open in the future to develop that relationship more fully. NRSP-9 recognizes that remaining viable in the future will require continued collaborations with NASEM but also new industry and government partners. This is where we see the value of the nonprofit arm of

NRSP-9 (additional wording is added to highlight the importance of the nonprofit in 2nd paragraph under Prerequisite Criteria). We recognize that NASEM Nutrient Requirement series have remained successful in part via NRSP-9; however, currently NASEM's efforts are largely independent of NRSP-9. Again, NRSP-9 recognizes the importance of NASEM, but needs to develop new collaborations moving forward.

The future demand is even greater if they can get more and sustained funding so that advertising could bring in more users successful use can bring in more and cetera. But they must have dedicated staff, not soft money post docs who are expected to do technical work while also doing publishable research. We need a better model.

This has been recently discussed. To be transparent, we do not really know the mechanism to implement a "permanent staff" presence to this project. We believe that this will involve the nonprofit arm of NRSP-9.

This has been a highly successful NRSP program, one that the USDA/ARS/NRC should use as a model. Yet even with the success to date it has been severely limited and has not truly met the original goals of coordinating nutrition of domestic animals, especially in the role of support of the NRC Nutrient Requirements, and of forming a highly used centralized feed database and nutrition research / diet formulation and optimization program. This has not been due to a lack of effort on the part of participants, but has truly been due to a severe lack of funding for the core staff and leaderships of a true Research Support Program.

We agree! The upper ceiling in terms of NRSP-9 impacts could be heightened with additional funding. The current renewal budget request represents a 49% increase from the 2020-25 NRSP-9 budget. Based on leveraged funding we are not requesting more at this time.

Increased coordination and cooperation with the NRSP 8 Genomic Capacity: Building Applied Genomic Capacity for Animal Industries program. The authors refer to some past work integrating genetic/genomic work into research, which has been a great start. But just as plant/crop production has been doing for years, we must connect the genetic changes in domestic animals directly with the changes in nutrient requirements, and I include in this the environmental impacts (by definition, changing the diet of domestic animals changes the environmental impact).

This is a very important point. The NRSP-9 has progressed its work with the understanding that accurate nutrient databases and requirement models will result in improving the efficiency of nutrient use by animals. This does have impacts on the environment and will be elucidated via the interactions among the Climate Smart Feed Management, Feed Composition, and Modeling Committees of NRSP-9. The actual point of reference for establishing the genetic potential of domestic animals will be determined outside NRSP-9 (i.e., NASEM and genetic improvement committees). Nonetheless, wording is included to highlight the potential to work with NRSP-8 (6th paragraph under Prerequisite Criteria).

The committee has made a great start with the creation of the 501 c 3 organization, and thus should be more explicit in stating as an objective to work with public and private entities (some of which they listed but should include the AFIA, the FDA, EPA, private companies (Cargill, whatever Purina is called now, etc.) A national checkoff system like 1 cent on a ton of food could produce a few million dollars per year for such an effort.

Again, wording is provided to elaborate on the role of the NRSP-9 nonprofit and potential contributors. Hopefully, others can take head of the checkoff suggestion, or look at a voluntary contribution from industry based on tonnage of feed produced annually – this is a great suggestion.

Reviewer 2

Again, thank you for recognizing NRSP-9 as a valuable resource

There are two minor weaknesses in the current proposal. First, it was very difficult to understand the proposed budget and review the budget tables, which were located at the end of the proposal. This format was probably due to the limitations of NIMSS, but it would have been easier to understand and review the budget, if the budget tables had been located on the same page (or in closer proximity to) the budget justification text.

We followed the budget format from the 2020-25 proposal. Because we have a significant number of nonpaid academic professionals, government officials, and partnering professional societies, we believe that illustrating the extent of leveraged funding is important. If the administrative advisors for the project have suggestions here as to formatting, those changes will be made.

The second minor weakness is the relative lack of detailed description of the 501c3 nonprofit arm that was recently established by NRSP-9. While the committee is commended for establishing a 501c3 component, it would have been helpful to know how the nonprofit will function and who will be involved in ensuring the successful development and implantation of this group.

This was brought forward by Reviewer 1 as well. In part, the NRSP-9 Coordinating is currently developing procedures to recruit funds to the nonprofit. Again, additional wording is provided to define the role of the nonprofit.

Reviewer 3

Complete integration into all NASEM Nutrient Requirement publications. Making data from NANP the “national” data set for nutrient requirements and modeling of livestock and companion animal (and potentially zoo animal) diet formulation This would be practical and

logical and give nutritional consultants and other professionals access to validated nutritional values from a variety of vetted laboratories from regions across the US.

We believe that we are working toward these ends. NASEM remains autonomous relative to the complement of their nutrient requirement series. The NRSP-9 has supported the development of the ingredient databases and nutrient requirement models used by NASEM. NRSP-9 will continue to develop database and modeling resources. Hopefully this will be done in conjunction with future NASEM nutrient requirement publications. It has been highlighted in the renewal the strong linkage between NASEM and NRSP-9.

Partitioning data by region of production is important, especially as the Climate-Smart Feed Management Committee initiates its effort.

The NRSP-9 Feed Composition Committee has discussed this on several occasions. There are potential industry partners that have indicated that these data are available for “certain” ingredients. Analytical laboratories are hesitant to provide additional descriptive metrics for ingredient analyses. Yes, we can add a sentence to the CSFM committee description (8th paragraph under Prerequisite Criteria).

The budget is highly leveraged and justified. To remain a sustainable entity, a nonprofit (501(c)3) arm of the NANP was established. Is there an opportunity to develop a licensing fee for diet formulation software companies to gain access to the data?

Although these discussions within the NANP Coordinating Committee have just been initiated, we added description of the ideas being discussed for revenue generation (2nd paragraph under Prerequisite Criteria).

Objectives and projected outcomes align with request for renewal. The opportunity exists to expand the data to all NASEM publications which support animal species.

This is clearly the idea moving forward with NRSP-9. Again, this will require a close working relationship with NASEM. Hopefully we have highlighted this in the revision as commented above.