

# NATIONAL ANIMAL NUTRITION PROGRAM

## NRSP-9

### **Duration:**

October 01, 2020 to September 30, 2025

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## **STATEMENT OF ISSUES AND JUSTIFICATION:**

### **Prerequisite Criteria:**

How is NRSP-9 consistent with the NRSP mission?

*Introduction to NRSP-9*

### **Overarching Specific Aims are:**

1. Support research efforts that enhance the sustainability, competitiveness, and profitability of U.S. agriculture by providing easily accessible and publicly available resources applicable to, and essential for, animal nutrition research.
2. Expand and enhance shared multispecies databases that can be integrated across species to ensure sufficient data are available to enable animal nutrition research aimed at improving human, animal, and environmental health.
3. Identify gaps within animal nutrition research that address global challenges such as adapting to and mitigating climate change; ensuring a safe, secure, and abundant food supply; heightening environmental stewardship; and improving human health, nutrition, and wellness.

The **Overarching Hypothesis** is that providing easily accessible and publicly available resources applicable to, and essential for, animal nutrition research will result in: 1) an improved basis for enhanced relevance of animal nutrition research, 2) enhanced development of animal feeds, diets, and nutrient supply, 3) applied drivers of increases in efficiency of food and fiber production, 4) a foundational platform for assessing, understanding, and mitigating nutrient related environmental impacts, 5) a core aspect of effectively addressing animal health and welfare, 6) an information base for informing regulatory actions regarding animal nutrition, feeding, and welfare, 7) provision of critical materials for educating and equipping the next generation of animal scientists, and 8) a basis for increased research efficiencies across research units within the United States and beyond.

To address our overarching hypothesis and aims, the NRSP-9 has, over the past 4 years, engaged 31

scientists from 22 institutions (see Appendix 1) and has:

Aim 1:

- Replaced the original website with a robust, mobile-friendly, easily navigable website that is currently being accessed by approximately 500 people monthly from over 50 countries. The website is simple and intuitive, includes orientations on how to use the database, provides in-depth information to support animal nutrition research, and has an increasing use trajectory.
- Collected, archived, and made available over 300 resources on animal nutrition modeling and statistics.
- Introduced and trained >600 people over the last 3 years in modeling techniques. Published 15 manuscripts and 54 abstracts for continued access to NRSP-generated information.
- Engaged monthly with the National Academy of Science, Engineering, and Medicine (NASEM) on relevant topics of research needs, databases, information accessibility, and subcommittees on Beef, Dairy, and Poultry nutrient requirements.

Aim 2:

- Revised all databases previously available on the website. More than 500,000 observations from 549 studies that evaluated animal performance and metabolism were uploaded. A basic framework to visualize data before download is available.
- Integrated animal performance data into a relational database management system. Free downloads are available to support modeling research across species. Information in the feed composition database is being used internationally in two projects (see Grand Challenge 4).
- Collected, screened, sorted, and archived over 4 million records of feed composition information from scientific literature and analytical laboratories. Methods for screening data and removing erroneous data were developed. The labor-intensive efforts are being automated for future data acquisition. Data are being used in the NASEM beef, dairy, and poultry requirements updates.

Aim 3:

- Evaluated literature on livestock responses to climate and identifying gaps in knowledge, and assessing their impacts on the accuracy of predictions from common nutrition models. An NRSP-9 postdoc evaluated the impact of ambient temperature on dairy calves' starter intake in support of the NASEM 2020 Dairy requirement revision.
- Implemented approaches for retention of research techniques and knowledge through video publication that were in danger of being lost.
- Engaged users and stakeholders through Feedback/Questions forms on the NRSP-9 website.
- Hosted numerous symposia at national society meetings and a 2019 Summit in Washington DC that contributed to identifying research gaps and focusing future research efforts in key NRSP-9 arenas.

To build and expand upon previous accomplishments and to address emerging needs, proposed **Specific Objectives** for the next 5-years include:

1. Develop easily searchable poultry feed composition database with real time data acquisition for NASEM Committee on Poultry Nutrition and integrate with others
2. Develop and foster relationships with commercial feedstuff laboratories for ongoing submission of feed analyses and automated feed ingredient data screening methodologies.
3. Initiate a more complete database description of carbohydrate fractions of feedstuffs to predict energy yield.
4. Expand multi-level training of modeling techniques to academic and industry nutritionists and graduate students across multiple species at professional meetings.
5. Retain institutional knowledge related to techniques and measurements critical to nutrition research.
6. Expand our social media platform to enhance client and stakeholder engagement.

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 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.

#### *Congruence with NRSP Mission*

The overarching aims and specific objectives of NRSP-9 are directly aligned with the mission of the NRSP. The primary focus is to develop enabling technologies, support research activities, and share facilities in an effort to stimulate high-impact research. By bringing researchers, modelers, technologies, and resources together, NRSP-9 has been able to accomplish what could not be realized by uncoordinated efforts. These diverse partnerships and collaborations have resulted in the acquisition of, and universal access to, feed nutrient composition and animal performance databases that are used to support nutritional models ranging from those predicting nutrient requirements to more complicated animal models. Data analyses and model development as well as key publications on modeling techniques have been assembled and provide a critical resource for the research community. Training of nutritionists in modeling techniques reduces future dependence on singular research studies to address nutritional questions. With this renewal, NRSP-9 will address existing and emerging needs of researchers primarily through the collection, evaluation, and dissemination of databases, informational resources, and nutrition research tools.

#### *Breadth of Research Activities Supported*

Linking nutrition with other areas of science has resulted in great strides in our knowledge and ability to improve animal agriculture production efficiencies. 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 genetic potential allows construction of diets more closely tailored to nutrient demands. Grouping animals based on genetic characterization to be fed more precisely thereby reduces production costs, increases efficiency of food production, and reduces environmental impact. Another example is linking nutrition with immunology to decrease dependence on antibiotics and maintain good animal health and welfare. Recent emphasis on mitigating climate change effects of and on animal agriculture has renewed interest in energetics to better understand responses to climate. These within- and cross-disciplinary linkages are crucial for many areas of animal science, and all contain some component that is grounded in nutrition. Better understanding of these linkages requires the collection 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 much wider 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.

## How does NRSP-9 pertain to national issues?

### *National Scope*

In 2018/2019, NASEM canvassed nearly 150 researchers and stakeholders in a wide variety of fields through a series of live events and webinars to identify ambitious scientific directions in food and agriculture. Through a consensus-building process, the committee identified the five most important initiatives that need to be addressed by food and agriculture research. The resulting publication (“Science Breakthroughs to Advance Food and Agricultural Research by 2030”; 2019; ISBN 978-0-309-47392-7) presented those initiatives in detail with one of those initiatives being: Expanding and analyzing the many pools of data involved in growing and producing food. The proposed NRSP-9 project fulfills this initiative.

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, and Equine Science Society. Through this involvement, the NRSP-9 team has been able to directly interact with researchers, educators, and industry professionals from across the U.S. at annual professional society meetings. The direct significance of NRSP-9 resources to stakeholders is underscored by the usage statistics for the website, which indicate the site garners 500+ pageviews per week from users throughout the United States and 57 other countries. During the most recent month, over 400 visitors were new. 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. Collectively, these metrics suggest that the data and tools provided by NRSP-9 are of interest and are useful to stakeholders nationally and internationally. We expect that user engagement will increase substantially within the next 5 years.

Governmental and non-governmental agencies around the U.S. are realizing and publicizing the value of animal agriculture to citizens. Nutrition can be argued as the most indispensable component of animal agriculture. 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*

The attendance of symposia/workshops indicates a demand for animal nutrition knowledge, and continued need for the NRSP-9 activities (more than 580 persons participated at the NRSP-9 symposia/workshops in 2019 alone). 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 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 genotype 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, 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. It is likely that 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., 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 fully understand the interaction of nutrition with immunocompetence. Dietary modification can be combined with other environmental factors to optimize immune response under a wide variety of 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 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 areas of research have 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 has 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 4,351 times. Citations on a worldwide basis would easily exceed 10,000 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.

The NRSP-9 provides essential material support to NASEM nutrient requirement subcommittees. Consequently, the impact of NRSP-9 is far reaching and anytime 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 an overarching need in broad animal research activities. Thus, the research support efforts of the NRSP-9 are an essential support network for NASEM and, consequently, the entirety of animal research.

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 nearly complete revision of the NASEM Dairy Cattle nutrient requirement document and the new NASEM Committee on Poultry Nutrition, 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. This paradigm shift will be further facilitated by NRSP-9 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 of each committee to collect data, code, and models from scratch thus greatly 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. This template and the preservation of data 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 in the form of rapid response beta-testing to decrease errors in the end product. By providing assistance with 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 better reflect current understanding of livestock nutrition rather than the mechanics of the models.

## **Rationale**

### Priorities 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 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

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.

*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 useful 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 more efficiently feed livestock and to produce safe and secure food. Many of the visits to the website are by individuals from developing countries where improved food security is of paramount importance. NRSP-9 aims to continue this contribution to international development by launching the website in multiple languages. Information in the feed composition database is being used internationally in two projects: 1) the Holos project of Agri-Food Canada that is a whole-farm model and software program that estimates greenhouse gas (GHG) emissions based on information entered for individual farms, and 2) the BASF animal nutrition branch, a global supplier of innovative feed additives for livestock, aquaculture, and companion animals, is using the feed names and definitions in an application that seeks to integrate nutrient data with environmental impact data for ingredients as part of a least-cost feed formulation package for customers. These types of global engagement and leadership are 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. The training of graduate students, postdoctoral scholars, and young professionals in modeling techniques enhances our global leadership in educational training and 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 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. 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 represents a major contribution 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 all compartments of the system are realistic. The NRSP-9 research support activities help the development of 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 (policy makers, representatives of the media, and those in interest organizations).

### *Stakeholder Involvement*

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 through interactions at professional conferences. Stakeholders have been a regular part of NRSP-9 annual meetings, symposiums, 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 (Federation of Animal Science Societies [FASS], 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) and the American Feed Industry Association (AFIA).

Current and future active participants in the NRSP-9 project (i.e., developing, reviewing, and distributing) have been and will continue to be drawn from primary stakeholder groups, particularly research scientists, teachers, extension professionals, producers and industry experts, relevant organizations, as well as 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 great 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 identify the areas of information that are most used by visitors.

### *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 in the animal excretion.

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 will complete efforts with the newly formed 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 and Poultry committees (as was done previously by the NRSP-9 with the NASEM Beef nutrient requirement committee). 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 that is already present in the literature.

NRSP-9 will follow 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 is for policy makers to highlight the relevance of animal nutrition research to improving global food security and how to produce animal foods in efficiently and sustainably. 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 on 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. In addition, a Keystone-like conference is 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.

## **IMPLEMENTATION**

## Objectives and Projected Outcomes

The immediate **Specific Proposal Objectives** are:

1. Develop an easily accessible and searchable feed composition database for the NASEM Poultry Committee and integrate this database with others.

Comments: Current NASEM nutrient requirement publications have static feed composition data until revised by the next committee. E.G., the previous poultry nutrient requirement estimates and feedstuff tables were published in 1994. Databases supporting the publications need to be updated, integrated, and made more accessible.

2. Develop and foster relationships with commercial laboratories for ongoing submission of feed analyses and automated data screening methodologies.

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.

3. Initiate a more complete database description of carbohydrate (CHO) fractions of feedstuffs to predict energy yield.

Comments: A complete CHO description is lacking in the literature for feedstuffs. These fractions are the primary components affecting usable energy for nonruminants and affecting fermentation characteristics in ruminants. Thus, the availability of this information affects total dietary cost and estimates of the impact of animal production on greenhouse gas emissions.

4. Expand multi-level training of modeling techniques to academic and industry nutritionists and graduate students across multiple species at professional meetings.

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.

5. Retain institutional knowledge related to techniques and measurements critical to nutritional research.

Comments: Without a detailed, descriptive library of research methodologies, the discipline of nutritional physiology risks loss of capabilities that have been developed as faculty retire and are not replaced.

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.

### Projected Outcomes/Impacts

Outcome/Impact 1: 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 environmental impact of animal production.

Outcome/Impact 2: Relationships with commercial laboratories for ongoing submission of feed analyses.

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.

Outcome/Impact 3: Database description of CHO fractions of feedstuffs to predict energy yield.

Comments: This information will minimize diet cost, improve stakeholder profitability, and enable environmental modeling researchers to be more effective.

Outcome/Impact 4: Expansion of modeling training at professional meetings.

Comments: This will enable and expand the predictive capabilities of researchers and thereby increase whole farm production efficiencies.

Outcome/Impact 5: Retention of institutional knowledge related to experimental techniques in nutritional research.

Comments: A detailed descriptive library of research methodologies avoids the regression of abilities in nutrition research and expands the actual potential use to less developed nations that look to the US for nutrition research leadership.

Outcome/Impact 6: Expansion of social media presence.

Comments: This increases the speed of information dissemination to stakeholders to facilitate rapid adoption and implementation of new knowledge.

**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 serves to connect 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. The resulting products support the research community, the commodity groups, industry, and government regulatory agencies by providing conclusive information and tools on nutrient requirements, feed composition, relationship of diet and health, nutritional efficiency, and modeling nutrient needs under various production conditions.

Three formal working committees (see Appendix 1) have been formed and have effectively served NRSP-9. These committees are:

#### 1. Coordinating Animal Nutrition Committee

The Coordinating Animal Nutrition Committee 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. The diverse structure of the Coordinating Animal Nutrition Committee (swine: Merlin Lindemann, Gary Cromwell, and Ryan Dilger; dairy: Don Beitz and Heidi Rossow; beef: Joel Caton; poultry: Todd Applegate and Ryan Dilger; equine: Nancy Irlbeck and Carey Williams; small ruminant: Joel Caton and Nancy Irlbeck; aquaculture: Del Gatlin; nutritional biochemistry: Donald Beitz) has brought different species expertise to the whole project. Appointments of committee members are made for multiple years with portions of the committee rotating off each year. The out-going 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 represents the groups of animal nutritionists that are selected through a competitive process administered by the Coordinating Animal Nutrition Committee and overseen by the Program Leader and Administrative Advisors. 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 10 members of the committee represent all species and the following institutions from the U.S.: University of Nebraska, University of Illinois, Washington State University, Pennsylvania State University, Auburn University, The Ohio State University, Cal-Poly – San Luis Obispo, University of Idaho, and DSM (industry).

### 3. Modeling Committee

The Modeling Committee represents the groups of animal nutritionists that are selected through a similar process to the Feed and Ingredient 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 10 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.

The feed composition databases, 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. 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*

The Regional Associations of Directors in the North Central, Northeastern, Southern, and Western Regions will designate their Regional Representatives to NRSP-9. These Administrative Advisors will provide policy guidance to the Coordinating Animal Nutritionist Committee 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; Level 5 Ag Consulting LLC), and David Benfield (North Central; The Ohio State University).

#### *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 to provide greatest public access to the benefits of the outcomes fostered by this project.

### Budget and Business Plan

#### *Budget*

The total estimated budget for NRSP-9 project is \$37,725,454 (a mean of \$7,545,091 per year, though each year differs), of which we are requesting mean MRF support of \$213,000 per year for each of the 5 years (Supplementary Tables 1 to 4). Funds for the Coordinating Animal Nutrition Committee (\$144,000 per year) will be used as follows: (1) \$122,000 for salaries and fringe benefits of the professional and technical support staffs; (2) \$6,000 for travel cost of committee members to annual on-site committee meetings; (3) \$15,000 for website maintenance and data management; and (4) \$1,000 for supplies. In addition, \$15,000 per year will be allotted to the NASEM to support travel and participation of a NASEM member with our three NRSP-9 committees. The Feed Composition and the Modeling Committees will each receive \$20,000, which will be used as follows: (1) \$10,000 to support salaries of a professional staff; (2) \$6,000 to support travel cost of Committee members to annual in-person committee meetings; (3) \$2,000 for supplies; and (4) \$2,000 for publication expenses.

Shared and in-kind costs from the members' institutions and industry will constitute \$7,292,091 (average) per year (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 in excess of 200,000 records.

In summary, requested MRF funding constitutes approximately 2.8% of the total project funding, with the other 97.2% of the support anticipated to come from industry and federal agencies in the form of grants or agreements and from, or be leveraged by, 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 with the passing of 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 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. The initial distribution of the requested annual funding in Year 1 will be as follows:

\$144,000 Coordinating Animal Nutrition Committee (including web site, feed database coordinator and modeling curator)

\$20,000 Feed Composition Committee

\$20,000 Modeling Committee

\$15,000 National Research Council

**\$199,000** Total MRF Requested

\$6,970,250 In-kind Institutional and Industry Support Anticipated

\$150,000 Leveraging (Grants [various Federal Agency and Industry]) Support Anticipated

**\$7,319,250** Total Estimated Budget

### *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 also is designed to help strengthen our national infrastructure of feed and modeling information to achieve higher levels of efficiency and impact in the animal nutrition research arena. This budget fully incorporates the NRSP9's Strategic Plan, with designated milestones, performance measures, and specific deliverables and can realistically estimate the in-kind and leveraging support based on current project experience. This ensures accountability for the investment.

A mean decrease of \$12,000/year in the proposed budget over the previous project budget would have been \$28,000/year but federal mandates in postdoc salaries resulted in an increase in that salary area. No increases have been requested in any other funding category. A cost-effective strategy has been proven over the past 5 years with NRSP-9 and its demonstrated productivity (8 refereed manuscripts and one video-accompanied manuscript as well as ca. 580 attendees from 11 countries on 5 continents at symposia and workshops in FY2019 alone) envisages continued success by the program. The initial project focus was on four major agricultural species. Additional species were added in the first (current) revision. Initial database and modeling efforts were on the four species but have now begun with the added species in this project period (e.g., a small ruminant grazing model on the website, a new section on aquaculture modeling on the website, a symposium on modeling at the Equine Science Society meetings, discussions of need for revision of aquaculture nutrient requirements following the 2019 Summit hosted by NANP). Incorporating and building on this strategy, the project now needs to continue to be responsive to

stakeholders by allowing for continued comprehensive information to fill gaps that will enhance the current work. Continuing to expand our activities in all species does not require an increase in budget because of similarities and complementarity in feeds, models, and research approaches. It does require funds to cover the acquisition of additional data, resources, and modeling training at societal meetings but those funds are being secured by non-MRF resources that the NRSP-9 committee will obtain.

The requested MRF funding is to support the facilitation activities of the Coordinating Animal Nutrition, the Feed Composition, and the Modeling Committees 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. Web development companies have been contracted to handle technical logistics of website improvement and data management. Funding for the Feed Composition and the Modeling Committees will be for salaries, travel, supplies, and publication expenses.

Aside from funds to support the committee activities, priority budget items reflected in this proposal are for continued support of a feed database coordinator and a modeling curator, employed as post-doctoral scholars. These post-doctoral scholars are essential to the research support provided by the maintenance of a global feed information system and modeling technologies.

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. Thus far, the effort is operating more economically than originally anticipated. When cost savings are realized at any point in time, known opportunities that have been verbalized by committee members are green-lighted for enhanced project productivity (e.g., the video bovine mammary biopsy manuscript to initiate the retention of research technique knowledge). 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 members and collaborators are contributed by the participating institutions. Supplies include materials to be shared with the Feed Composition Committee and the Modeling 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 to the NRSP-9 webpages as outlined in the contracts with the web development companies hosting the pages. Funds are also requested to support travel of the Feed and Ingredient Composition Committee and the Modeling 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 at least one 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 and the Modeling 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 and Documentation of Research Support**

### **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 the NRSP realm, leveraging helps both the NRSP-9 activity and the greater community at large (i.e., university systems, industry, government, nonprofits). In the case of NRSP-9, initial investments have leveraged a tremendous return. Table 1 provides examples of funding leveraged from multiple sources.

**Table 1.** Multiple mechanisms and sources of funding leveraged by NRSP-9.

<b>NRSP-9's Contribution</b>	<b>Value</b>	<b>Leverage</b>	<b>Partners<sup>a</sup></b>
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 <sup>b</sup>	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 nutrition efforts	\$300,000	Research support to the NASEM efforts helped leverage \$300,000 in sponsor support to establish nutrient requirements of poultry for use by researchers.	American Feed Industry Foundation (IFEEDER, non-profit foundation) NASEM (private, non-profit)
Research support to national dairy nutrition efforts	\$300,000	Research support to the NASEM efforts helped leverage \$300,000 in sponsor support to establish nutrient requirements of dairy cattle for use by researchers.	American Dairy Science Association Foundation (non-profit foundation) Industry (private, for profit).
Professional society workshops and symposia	\$65,691	Two funded proposals for conference support. The second funded proposal is for the 2019-2021 period.	NIFA/USDA support programs
Professional society symposium	\$5,500	Support for the 2019 Poultry Science Association initial introduction to the potential for modeling in poultry nutrition.	Industry (private, for profit).
NANP website support	\$1,200	Provided funds for domain name acquisition.	Industry (private, for profit).
<b>Total leveraged support:</b>	<b>\$89,712,391</b>		

<sup>a</sup>Partners contributed the funds or nominal value listed in the Value column.

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

The funds leveraged by NRSP-9 to support animal-nutrition research are significant. A total investment of \$1,125,000 over the current 5-year NRSP-9 project period has already leveraged additional resources valued at \$89,712,391 resulting in a total of \$90,837,391 available to support NRSP-related national animal nutrition research effort – a sum that is more than 80 times the original NRSP investment. 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 for stakeholders to refine the mean nutrient values and the variation associated with those mean values for the particular feedstuffs that they are using has tremendous value. An increase in the precision (the reduced error term for variation) of the values for each feedstuff allows stakeholders to use less formulation overages 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 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 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**

### Overall Plan

#### *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 website components. 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 policy makers, 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 an NANP

newsletter and a growing focus on social media interactions (i.e., LinkedIn, YouTube, Twitter, Facebook, and ResearchGate) provide a diverse array of 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*

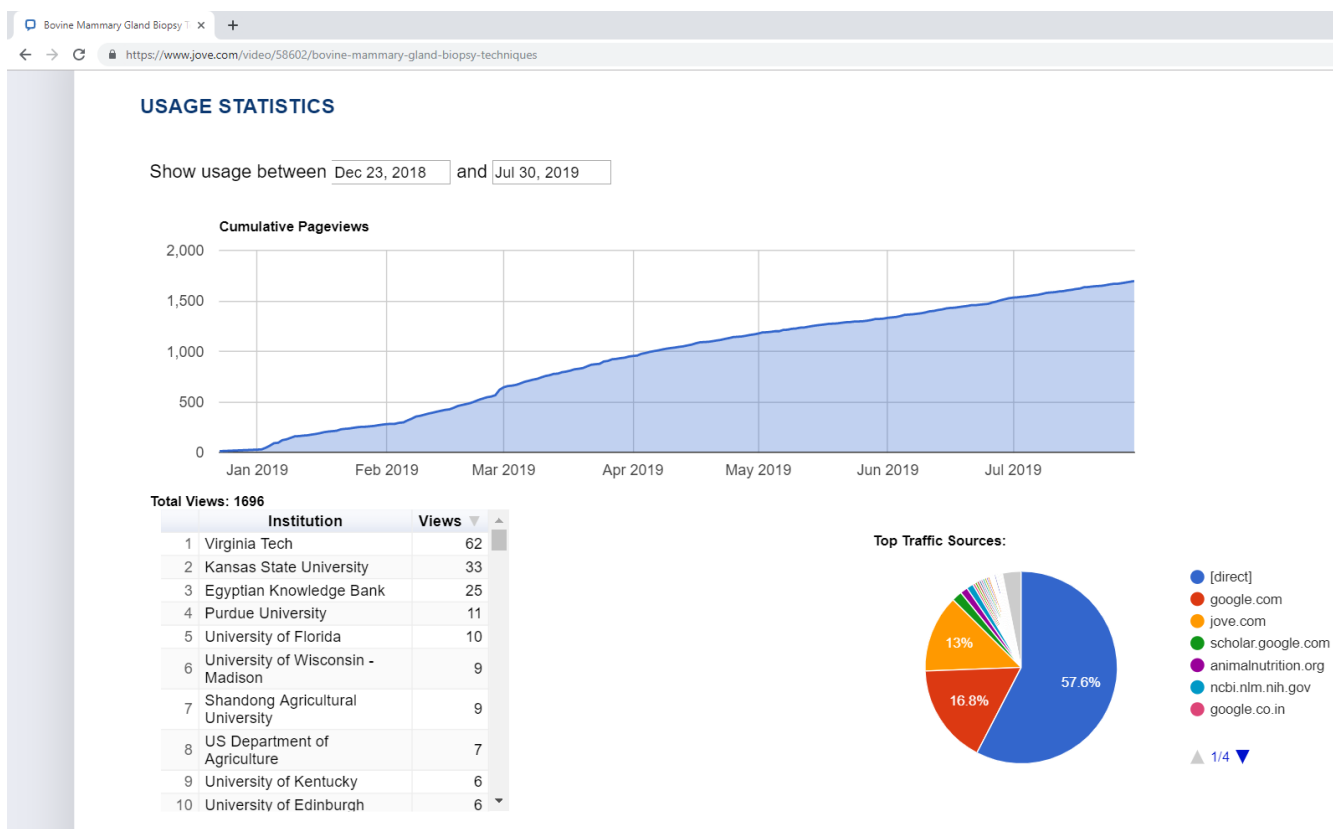
Accomplishments and impacts of NRSP-9 will be measured directly by the level of success in accomplishing the goals and by meeting the deliverables set out in the Strategic Plan. Reports of research support activities through commonly viewed channels such as peer-reviewed journals will be tracked and evaluated in terms of impact. As such, number (Table 2) 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 7 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.

**Table 2.** 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	8*		20	
<b>Total</b>	<b>15</b>	<b>1</b>	<b>54</b>	<b>5</b>

\* One peer-reviewed publication is in “accepted with minor revision” status. 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>)

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



Members of NRSP-9 also evaluate the accomplishments and impacts of the research support by monitoring stakeholder usage of digital resources (e.g., number of newsletter recipients, website user tracking statistics, and social media engagements). By relying on stakeholder usage metrics, NRSP-9 members get a more accurate and more 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 determine indirectly the potential impact of these different website components. Users who find value in a page divert more of their time to that resource. By relying on stakeholder usage metrics, NRSP-9 members get a more accurate and more 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 saturation of NRSP-9 utility within the stakeholder community. An example of the value of the revised website is provided in Table 3. 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 assure that activities are meeting program objectives.

**Table 3.** Comparative website usage since inception of the new website

Metric	Period Covered		% Change	Explanation
	March 2018	June 2019		
New users (unique)	249	473	+90.0	Adding unique users at twice the rate
New user countries	49	58	+18.4	Adding new users from more countries

New U.S.-based users, % of total new users	43	51	+9.4	Greater visibility of NANP website within the U.S.
Returning users	48	104	+116.7	More users return to the website repeatedly
Sessions	342	789	+130.7	Users are returning to the website for twice as many sessions
Sessions per user	1.37	1.51	+10.3	Users return to the NANP website more frequently than when it first launched
Pageviews	1,365	2,471	+81.0	Users are viewing more content each time they return to the website
Pages/session	3.99	3.13	-21.5	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)
Count of sessions lasting 1-3 minutes	46	87	+89.1	Indicates user attention is being held by current website longer than before
Average session duration	00:04:05	00:04:07	-0.5	No real change in how long a user remains on the NANP website

### *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 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 the 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 make sure 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

In the first year of NRSP-9, 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. By the second year, NRSP-9 was 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, and crop composition from all over the world. 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.

Activities of the NANP have enabled critical analysis of animal science research and animal agriculture's impact on human health and wellbeing. An article by Robin White (NRSP-9 post doc at the time) and Mary Beth Hall (founding member of NRSP-9), Nutritional and Greenhouse Gas Impacts of Removing Animals from US Agriculture, was published in *Proceedings of the National Academy of Sciences* (PNAS 2017;114:E10301-E10308). The idea for the paper evolved from discussions during the 2015 NRSP-9 Summit on Animal Nutrition Research Priorities for a Healthy Society. This paper ranks in the top 5% of all research outputs scored by Altmetric for PNAS and its abstract has been downloaded 81,500 times. A related publication was co-authored by another member of the NRSP-9 Coordinating Committee (Odle J, et al. The Potential Impact of Animal Science Research on Global Maternal and Child Nutrition and Health: A Landscape Review. *Advances in Nutrition* [Bethesda, MD]. 2017;8:362-381). Articles such as these contribute to the dialog among decision makers regarding agriculture and food policy, particularly as related to food security and human health.

The 2015 summit, opened with a presentation by the Under Secretary of the U.S. Department of Agriculture, served to highlight research needs in animal nutrition and involved a wide realm of interests and disciplines from around the world. The summit proceedings were translated and published online in five different languages: English, Spanish, Portuguese, Chinese, and Korean (<https://animalnutrition.org/summits>). A second summit entitled Producing Food with Animals: Sustainability, Efficiency, and Security in the US was conducted in 2019. It opened with a presentation on "Global strategies for animal protein for humans" by Sir Charles Godfray, Professor and Director of the Oxford Martin School at the University of Oxford in Oxford England. Publications from this summit

are in development.

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 exchange of information and development of capabilities among students, university researchers, and industry professionals. Conducted yearly at the American Dairy Science Association (ADSA) annual meetings, these workshops have received more interest than can be accommodated (i.e., registration reached the maximum of 100 in both 2017 and 2018 with many people on a waiting list for possible openings; attendance at 2019 workshops/symposia at ASAS, ADSA, and PSA exceeded 400). Attendees reached through these workshops reflect the wide realm of stakeholders that NRSP-9 serves, especially future generations of researchers. Introductory (Level 1) and advanced (Level 2) modeling workshops have been conducted at ADSA with intent to rotate those again or to perhaps add a Level 3 workshop. A Level 1 workshop has been conducted at ASAS. The current intent is to offer Level 2 next year at ASAS and Level 1 at PSA.

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 2019, the collective modeling database and associated resources received 372 pageviews (12.4 per day), the feed composition database received 313 pageviews (10.4 per day), and the NASEM nutrient requirement model pages received 156 pageviews (5.2 per day). The workshops and symposia section of the website was viewed by 89 unique visitors in June 2019, which suggests stakeholder engagement continued beyond the in-person 2019 Summit. Overall, the digital resources provide a robust system of integrated platforms 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 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, quantity and impact of publications will be measured, and stakeholder feedback will continually be assessed as components of an evaluation methodology. Website metrics also will be tracked with greater care to ensure more available data to evaluate impact. 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 to also utilize additional, more interactive communication approaches such as webinars and social media activity.

**Supplementary Table 1. Requested NRSP-9 direct funds budget**

<b>Description<sup>a</sup></b>	<b>FY2021</b>	<b>FY2022</b>	<b>FY2023</b>	<b>FY2024</b>	<b>FY2025</b>	<b>5 Yr Totals</b>
Salaries <sup>b</sup>						
Committee Chairs	\$30,000	\$30,000	\$30,000	\$30,000	\$30,000	\$150,000
Database coordinator (post doc)	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	\$250,000
Modeling coordinator (post doc)	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	\$250,000
Administrative Assistant (25%)	\$12,000	\$12,000	\$12,000	\$12,000	\$12,000	\$60,000
Fringe Benefits	\$0	\$0	\$0	\$0	\$0	\$0
Travel	\$18,000	\$18,000	\$18,000	\$18,000	\$18,000	\$90,000
Mid-term external review			\$20,000			\$20,000
Summit				\$50,000		\$50,000
Supplies <sup>c</sup>	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$25,000
Website maintenance and data management	\$15,000	\$15,000	\$15,000	\$15,000	\$15,000	\$75,000
Publications	\$4,000	\$4,000	\$4,000	\$4,000	\$4,000	\$20,000
National Research Council	\$15,000	\$15,000	\$15,000	\$15,000	\$15,000	\$75,000
<b>Total</b>	<b>\$199,000</b>	<b>\$199,000</b>	<b>\$219,000</b>	<b>\$249,000</b>	<b>\$199,000</b>	<b>\$1,065,000</b>

<sup>a</sup>Dollars provided will be split among the Coordinating Committee, Feed Composition Committee, and Modeling Committee.

<sup>b</sup>Salaries are for professional and technical support staff for coordinating meetings, developing and distributing materials, and for data input. Fringe benefits on the Coordinators are to be provided by the host institution. Salaries of members and collaborators are contributed by the participating institutions.

<sup>c</sup>Supplies include computer supplies and software for maintaining databases and computer information servers, shipping costs, publication costs, postage, and communications activities.

**Supplementary Table 2. Leverage in-kind; Institutional salary support, indirect costs, other institutional costs, value of feed analyses, travel, and publications costs**

<b>Description</b>	<b>FY2021</b>	<b>FY2022</b>	<b>FY2023</b>	<b>FY2024</b>	<b>FY2025</b>	<b>5 Yr Totals</b>
<b>Salaries<sup>a</sup></b>						
Committee members (SY)	\$330,000	\$336,600	\$343,332	\$350,199	\$357,203	\$1,717,333
Technical support (TY)	\$90,000	\$91,800	\$93,636	\$95,509	\$97,419	\$468,364
Administrative support	\$67,500	\$68,850	\$70,227	\$71,632	\$73,064	\$351,273
Fringe benefits	\$97,500	\$99,450	\$101,439	\$103,468	\$105,537	\$507,394
Institutional indirect cost	\$146,250	\$149,175	\$152,159	\$155,202	\$158,306	\$761,091
<b>Institutional support<sup>b</sup></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
Feed analysis and ingredient composition <sup>c</sup>	\$6,000,000	\$6,000,000	\$6,000,000	\$6,000,000	\$6,000,000	\$30,000,000
Travel <sup>d</sup>	\$15,000	\$15,000	\$15,000	\$15,000	\$15,000	\$75,000
Publications <sup>e</sup>	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	\$25,000
<b>Total</b>	<b>\$6,970,250</b>	<b>\$6,984,875</b>	<b>\$6,999,793</b>	<b>\$7,015,008</b>	<b>\$7,030,529</b>	<b>\$35,000,454</b>

<sup>a</sup>Institutional salary support contributions calculated at 0.10 FTE per committee member (30 committee members) with an average salary of \$110,000/year. Technical support is calculated as 0.10 FTE for 20 technicians supporting scientists on the project and an average technical salary of \$45,000/year. Administrative support is calculated as 0.05 (FTE) per year for 30 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 all years.

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

<sup>c</sup>Estimated as the value of an additional 200,000 feed analyses added to the database per year at \$30/sample.

<sup>d</sup>Travel in-kind support was calculated as 30 scientists as \$500/year for each scientist. Funding sources will vary but include institutional and industry contributions.

<sup>e</sup>Publication in-kind support consists of anticipated industry and professional society support for publications.

**Supplementary Table 3. Leverage, Anticipated grant support**

<b>Description</b>	<b>FY2021</b>	<b>FY2022</b>	<b>FY2023</b>	<b>FY2024</b>	<b>FY2025</b>	<b>5 Yr Totals</b>
Grant description						
Postdoctoral grants <sup>a</sup>	\$0	\$0	\$125,000	\$250,000	\$125,000	\$500,000
Conference grants and symposium leveraging <sup>b</sup>	\$30,000	\$30,000	\$30,000	\$30,000	\$30,000	\$150,000
Research Grants <sup>c</sup>	\$120,000	\$180,000	\$210,000	\$180,000	\$120,000	\$810,000
<b>Total</b>	<b>\$150,000</b>	<b>\$210,000</b>	<b>\$365,000</b>	<b>\$460,000</b>	<b>\$275,000</b>	<b>\$1,460,000</b>

<sup>a</sup>Postdoctorals hired onto the project will be encouraged and assisted to write postdoctoral fellowship grants for two years of salary funding, travel, publication, and a small amount of operating expenses. 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, NRSP-9 funds will be used to hire an additional postdoc. Consequently, we plan to leverage 2 postdoc positions into 4.

<sup>b</sup>As symposiums at conferences are a key component of NRSP-9 activities, funds will be actively recruited to support these activities. The \$30,000 per year represents \$20,000 in funded grants annually and another \$10,000 in direct support from co-sponsoring professional societies and professional organizations.

<sup>c</sup>These funds represent extramural grant funds secured by members of the NRSP-9 team. These are funds that support research into key NRSP-9 areas and are led by NRSP-9 team members. There are currently 30 NRSP-9 scientists on the team and the leveraged dollar estimate is likely low. Accurate records will be maintained on this type of leveraging and reported annually.

**Supplementary Table 4. Total projected NRSP-9 budget including direct and leveraged funds**

<b>Description</b>	<b>FY2021</b>	<b>FY2022</b>	<b>FY2023</b>	<b>FY2024</b>	<b>FY2025</b>	<b>5 Yr Totals</b>
Requested NRSP-9 direct funds (from Table 1):	\$253,000	\$253,000	\$253,000	\$253,000	\$253,000	\$1,265,000
Anticipated leveraged in kind support (from Table 2):	\$6,970,250	\$6,984,875	\$6,999,793	\$7,015,008	\$7,030,529	\$35,000,454
Anticipated leveraged grant dollars (from Table 3):	\$150,000	\$210,000	\$365,000	\$460,000	\$275,000	\$1,460,000
<b>Total projected NRSP-9 budget from all sources:</b>	<b>\$7,373,250</b>	<b>\$7,447,875</b>	<b>\$7,617,793</b>	<b>\$7,728,008</b>	<b>\$7,558,529</b>	<b>\$37,725,454</b>

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

### ***Coordinating Animal Nutrition Committee:***

#### **Merlin Lindemann (Chair)**

- University of Kentucky
- Swine Nutrition

#### **Ryan Dilger (Representing the Feed Composition Committee)**

- University of Illinois
- Swine/Poultry Nutrition

#### **Joel Caton**

- North Dakota State University
- Beef, Small Ruminant Nutrition

#### **Heidi Rossow (Representing the Modeling Committee)**

- University of California-Davis
- Dairy Nutrition

#### **Jack Odle**

- North Carolina State University
- Swine Nutrition

#### **Nancy Irlbeck**

- Washington State University
- Horse, Small Ruminant Nutrition

#### **Don Beitz**

- Iowa State University
- Dairy, Metabolism

#### **Delbert Gatlin**

- Texas A&M University
- Aquaculture

#### **Todd Applegate**

- University of Georgia
- Poultry Nutrition

#### **Carey Williams**

- Rutgers State University
- Equine Nutrition

#### **Gary Cromwell (Past-Chair)**

- University of Kentucky
- Swine Nutrition

***Feed Composition Committee:***

**Phil Miller (Chair)**

- University of Nebraska
- Swine Nutrition

**Bill Weiss**

- The Ohio State University
- Dairy Nutrition

**Ryan Dilger**

- University of Illinois
- Swine, Poultry Nutrition

**Mark Edwards**

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

**Mark Nelson**

- Washington State University
- Beef Nutrition

**Brian Small**

- University of Idaho
- Aquaculture

**Alexander Hristov**

- Pennsylvania State University
- Dairy Nutrition

**Casey Bradley**

- DSM Animal Nutrition
- Swine Nutrition

**William Dozier**

- Auburn University
- Poultry Nutrition

**Michael Lilburn**

- The Ohio State University
- Poultry Nutrition

***Modeling Committee:***

**Mark Hanigan (Chair)**

- Virginia Tech University
- Dairy Nutrition

**Ermias Kebreab**

- University of California-Davis
- Environmental Nutrition

**Mike VandeHaar**

- Michigan State University
- Dairy Nutrition

**Heidi Rossow**

- University of California-Davis
- Dairy Nutrition

**Luis Tedeschi**

- Texas A&M University
- Beef Nutrition

**Tim Hackmann**

- University of Florida
- Rumen Microbiology

**John McNamara**

- Washington State University
- Ruminant Nutrition

**Peter Ferket**

- North Carolina State University
- Poultry Nutrition

**Nathalie Trottier**

- Michigan State University
- Swine Nutrition

**Dominique Bureau**

- University of Guelph
- Aquaculture