

NATIONAL ANIMAL NUTRITION PROGRAM

NRSP-9

Duration:

October 01, 2015 to September 30, 2020

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STATEMENT OF ISSUES AND JUSTIFICATION:

Prerequisite Criteria:

How is NRSP-9 consistent with the NRSP mission?

Introduction to NRSP-9

At the conception of NRSP-9, there were no science-based, up-to-date syntheses of data, teaching tools, or prediction technologies for animal nutrition research. As a result, outdated and inconsistent information was being used: (1) as the basis for animal nutrition research; (2) in the development of animal diets, feeds, and foods; (3) as the applied driver of efficiency in food and fiber production; (4) as the foundation for dealing with environmental impact; (5) to address animal well-being and meet requirements in the Animal Welfare Act; (6) in regulatory actions involving animal nutrition, feeding, and welfare; (7) and as the basis for educating the next generation of animal scientists. Research efficiency was not optimal as multiple groups were spending time synthesizing the same data to use for research efforts. To address this gap in research support, the **overarching aims of NRSP-9 are to:**

1. Support research efforts that enhance the sustainability, competitiveness and profitability of U.S. agriculture by providing easily accessible and publically available resources applicable to, and essential for, animal nutrition research.
2. Expand and enhance shared databases and integrate across species to ensure sufficient data are available to enable animal nutrition research aimed at improving human, animal, environmental, and economic health.

3. Identify gaps within animal nutrition research that will help to 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.

Over the last 5 years, NRSP-9 has begun to address these aims (1, 2, and 3) by:

Aim 1:

- Developing a website for animal nutrition research resources that is currently being accessed by approximately 200 people per month from over 30 countries throughout the world.
- Collecting over 100 resources on animal nutrition modeling and statistics including methods papers; model, data handling, and statistical code; and software reviews for researchers.
- Renovating two highly valued nutrient requirement software products to function on modern computers and making these available for teaching, research, and field use.
- Recommending individuals as members and co-chairs for the new National Research Council's (NRC) Committee on Dairy Cattle Nutrition and the NRC Committee on Beef Cattle Nutrition.

Aim 2:

- Integrating private data to promote the free sharing of information for the advancement of knowledge and understanding of animal nutrition.
- Collating several animal performance datasets collectively representing the preservation of work from approximately 165,000 research hours and encompassing over 500 animal studies.
- Collecting, screening and sorting nearly 1.5 million records of feed composition information so they can be accessed and downloaded from the NRSP-9 website. Some of this data has been used in the upcoming NRC beef cattle update.

Aim 3:

- Evaluating literature on livestock responses to climate and identifying gaps that exist within this literature and their impacts on the accuracy of predictions from common nutrition models.
- Launching a website-based feedback forum to solicit comments from stakeholders about concerns with, or questions about, nutrient requirement models.

In an attempt to continue this effort, **the short term objectives for the next 5-year cycle are to:**

1. Assist the NRC Committee on Dairy Cattle Nutrition by developing a feed composition database that can be used across species.
2. Provide a forum for discussion and development of a research agenda that elucidates how animal nutrition can best be applied to improve animal performance, efficiency, and health, while minimizing environmental impact.
3. Provide advice on analytical methods of feed analysis.
4. Provide research and application modeling support.
5. Develop and implement a communications plan.

The relation of these activities with the outlined goals of a NRSP are detailed in the following sections. Through these efforts, NRSP-9 will attempt to further its usefulness as a unified data repository and resource center for the animal nutrition research community.

Congruence with NRSP Mission

The goals of NRSP-9 are directly aligned with the mission of the National Research Support Projects as 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 single, uncoordinated

efforts. These diverse partnerships and collaborations have resulted in delivery of databases of feed nutrient composition and animal performance that are used to support nutritional models ranging from those predicting nutrient requirements for several livestock species to more complicated animal models. A selection of examples of data analyses and model development as well as key publications on modeling techniques have also been assembled thus providing a critical resource for the community. With this renewal, NRSP-9 will continue to address the 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 production efficiencies in animal agriculture. For example, a tremendous amount of new genetic information has recently become available, and several large projects are in progress around the world to derive genomic prediction equations for key productive, nutritionally linked traits such as feed efficiency. Defining nutrient requirements or nutritional responses as functions of the animal's genetic potential will allow construction of diets more closely tailored to the exact needs of individual animals. One could also group animals based on genetic characterization so that the group of animals could be fed more precisely. 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 on animal agriculture has renewed interest in energetics to better understand responses to climate. Finally, nutrition has been coupled with economics, sociology, and environmental science to develop preliminary assessments of on-farm management to improve food production sustainability. 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 those potential linkages requires the collection and mining of very 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 widely 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. Data and data analyses are no longer restricted to only those individuals working with the group who originally collected the data. Many of these research areas are expanding, and continued support from NRSP-9 activities will promote the efficient advancement of new knowledge in these sectors. By providing globally accessible research and education tools vital to improving the nutrition industry, 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

Members of NRSP-9 currently encompass scientific expertise from the beef, dairy, poultry, and swine industries from all regions of the U.S. 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 and the Poultry Science Association. 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 300 to 500 pageviews per week from users throughout the United States and in over 30 countries. On a weekly basis, approximately half the visitors are 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.

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. The group also plans to expand its focus to collect and make available data and tools relevant to horses, small ruminants (sheep and goats), and aquaculture species, that will similarly magnify the relevance of the project. Through these planned expansions, NRSP-9 will solidify its applicability as a unified nutritional information repository essential to animal agricultural stakeholders across the U.S. and the world.

Continued Need

The continued need for the NRSP-9 research support activities is 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 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. 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.

The relevance of NRSP-9 in the immediate future is also evidenced by current efforts to improve animal nutrient requirement models. Interactions with the NRC committees of the National Academy of Sciences have provided a primary avenue of research support utility within NRSP-9. With the recent identification of the new NRC Committee on Dairy Cattle 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 like those provided by the NRC. This paradigm shift will be facilitated by NRSP-9 through the provision of a standard platform for a feed composition database and the preservation of the feed composition data collected by the NRC committee for use by researchers and the next dairy NRC committee. 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 of those efforts. Initial efforts toward this new structure have already been successfully enacted with the NRC Committee on Beef Cattle Nutrition. This template and the preservation of data can serve as a model for future improvements to nutrient requirement models. Furthermore, as beta versions of NRC 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 NRC model updates, NRSP-9 efforts enable 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.

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 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 which 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. 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 site in multiple languages. The expansion of NRSP-9 resources to include small ruminants and aquatic species will 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.

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

Literature surveys 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 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 submodels 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, 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 voluntary 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 in an era

of transition; (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 forum and through interactions at professional conferences. Stakeholders have been a regular part of NRSP-9 annual meetings. 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).

In the future, NRSP-9 plans to solicit forum interactions from specific stakeholder groups to gather feedback on currently available nutritional modeling systems. The group also plans to develop a networking community database for users to identify experts in various fields of interest, thereby linking researchers, fostering new collaborating and facilitating efficient research. 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, stakeholder's 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 and dairy cattle 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 the by publication citation indices.

Renewal Justification

Although NRSP-9 has made great strides toward meeting the needs of stakeholders, there are substantial contributions that can still be made. In its current term, NRSP-9 has considerably improved availability of data and nutritional resources. Nearly 1.5 million records of feed composition from commercial laboratories have been collected, synthesized and made available for public download. This serves as a valuable resource for the entire nutrition community. Industry professionals can consult tables to determine both the average and variance of nutrient specifications for over 200 ingredients. 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.

Software programs running the NRC models for calculating beef and dairy cattle nutrient requirements were updated to run on modern computers. The committee will continue to collect information from stakeholders regarding software and model concerns with the NRC 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 NRC committees thus improving the speed of model improvement. NRSP-9 will also work with the newly formed NRC Committee on Nutrient Requirements of Dairy Cattle to establish a common software framework that can be used across species which will ensure higher adoption of the programs for teaching and research purposes and improve ease of use for producers and nutritional professionals.

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 collection. This improves research efficiency by providing the ready to use resources that researchers need. The animal performance database will be expanded with data from the current NRC Beef and Dairy committees and the soon to be formed Poultry committee. Making these data available will further 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.

NRSP-9 is planning a summit in Washington D.C. in early spring of 2015 for policy makers to highlight the relevance of animal nutrition research to improving global food security. The group plans to hold a symposium and a workshop in summer of 2015 to educate researchers, industry professionals, and students about feed composition concerns in addition to modeling techniques and approaches. The symposium and workshop talks will 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 which will help improve research training and efficiency, and educate policy makers and the general public through release of the materials on the website.

IMPLEMENTATION

Objectives and Projected Outcomes

The NRSP-9 Coordinating Animal Nutrition Committee developed a Strategic Plan during its initial 5-year period of funding which has guided the efforts of the overall group. As that original plan remains intact, those goals and deliverables are outlined below. These objectives are designed to build on progress to date, outlined in the Statement of Issues and Justification.

Objectives and Deliverables for 2015 - 2020

Short-term Goals (2016-2018)

1. Assist the NRC Committee on Dairy Cattle Nutrition by developing a feed composition database that can be used across species.

Deliverable: A standard platform that will be useable for all NRC publications.

Deliverable: A publically available, continually updated, web based, feed information system that contains information on beef and dairy cattle, swine, poultry, horses, small ruminants, and aquaculture species.

2. Provide a forum for discussion and development of a research agenda that elucidates how animal nutrition can best be applied to improve animal performance, efficiency, and health, while minimizing environmental impact.

Deliverable: A series of targeted summit meetings to discuss issues critical to the animal-nutrition research community. The first summit will take place in early 2015. Talks will be recorded, summarized, and posted on the NRSP-9 website.

3. Provide advice on analytical methods of feed analysis.

Deliverable: A critical review on evolving non AOAC-approved analytical methods for feed analysis.

4. Provide research and application modeling support.

Deliverable: Provide beta-testing and between-release support of nutrient requirement software for NRC committees.

Deliverable: A forum to foster computer code sharing and a critical discussion on analysis methods; computing problems; and potential solutions to those problems.

Deliverable: A collection of resources describing how to conduct modeling and code demonstrating such use available for download by the research community.

5. Develop and implement a communications plan.

Deliverable: Mechanisms to engage and inform stakeholders of what we are doing including regular articles in society newsletters, posters at national meetings, and invitations to key stakeholders to NRSP-9 meetings.

Future Goals (2017-2020)

1. Determine limitations of currently available feed characterization assays.

Deliverable: Conduct a survey of nutrition scientists and convey results on limitations of current assays.

2. Establish an interactive, low-maintenance, web-based collaborative expert network.

Deliverable: A network of experts for use by government agencies, public and private researchers, feed industry, livestock producers, and educators, and extension workers.

Deliverable: A searchable database to identify trends in animal nutrition research publications.

3. Facilitate model development.

Deliverable: Develop a uniform modeling platform for use by future NRC committees.

Deliverable: A computing code forum designed to host user-uploaded and NRSP-9 code samples for education, research use, and discussion.

4. Identify emerging or urgent topics for the research community

Deliverable: Write topical reviews that have been identified by NRSP-9 or stakeholders.

Deliverable: Systematic assessment and testing of currently available nutritional models to identify areas where additional research is needed.

5. Develop an electronic forum to help maintain knowledge, catalogue research-support resources, and ensure continuity between editions of NRC requirement publications.

Deliverable: Correcting errors in the model code, making limited changes based on compelling needs, and collecting information for future use via a web-based forum.

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 working committees 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: Gary Cromwell, Phillip Miller, and Jack Odle; dairy: Mark Hanigan, William Weiss, and Mary Beth Hall; beef: Mike Galyean; poultry: Todd Applegate; nutritional biochemistry: Donald Beitz) has brought different species expertise to the whole project. Appointments of committee members are made for three years with one-third of the committee rotating off each year. The out-going members will coordinate with the new members and the Chair of Coordinating Animal Nutrition Committee to ensure a smooth transition period. Three additional nutritionists in the fields of small ruminant nutrition (sheep and goat), horse nutrition, and aquaculture (fish and shrimp) nutrition will be recruited to provide needed expertise to the renewed project.

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.

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 feed composition databases, nutrient requirement models, and animal performance information of the four initial species (swine, beef, dairy, and poultry) were established during the first 5-year project. In the renewed project, at the request of stakeholders, data and resources of three additional species (e.g., small ruminants, horses, aquatic species) will 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.

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 Nancy Cox (Southern; University of Kentucky), Cameron Faustman (North Eastern; University of Connecticut), Bret W. Hess (Western; University of Wyoming), 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://nanp-nrsp-9.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 \$2,544,000 per year, of which we are requesting MRF support \$225,000 per year for a total of 5 years (Supplementary Table 1). Funds for the Coordinating Animal Nutrition Committee (\$144,000 per year) will be used as follows: (1) \$111,000 for salaries and fringe benefits of the professional and technical support staffs; (2) \$12,000 for travel cost of committee members to annual meetings; (3) \$20,000 for website maintenance and data management; and (4) \$1,000 for supplies. In addition, \$25,000 per year will be allotted to the National Academies to support travel and participation of a National Research Council member with our three NRSP-9 committees. The Feed Composition and the Modeling Committees will each receive \$28,000, which will be used as follows: (1) \$12,000 to support salaries and fringe benefits of a professional staff; (2) \$12,000 to support travel cost of Committee members to annual 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 \$2,319,000 per year (Supplementary Tables 2 to 4). 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 have been significantly leveraged. Nearly 1.5 million records of feed composition data from analytical labs have been donated to the NRSP-9 feed databases. Once the NRC Committee on Dairy Cattle Nutrition begins to make progress, another 1 million records are anticipated.

In summary, requested MRF funding constitutes approximately 8.8% of the total project funding, with the other 91.2% 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 fill the current continued void in nutrition research support information and technology. It is anticipated that the gaps at the transition period will have been filled and a foundation set for others to assume greater responsibility for funding and/or carrying out these activities. After a backlog is filled, and information is updated through the work outlined in this NRSP proposal, the governmental, industrial, and nonprofit communities will be poised on firm footing to assume financial responsibility for continuing the work. Strong networks will have been built through the NRSP and a broad base of supporters will have been established to carry out the work in the future. The initial distribution of the requested annual funding will be as follows:

- \$144,000 Coordinating Animal Nutrition Committee (including web site, feed database coordinator and modeling curator)
- \$28,000 Feed Composition Committee
- \$28,000 Modeling Committee
- \$25,000 National Research Council
- \$225,000 Total MRF Requested
- \$2,219,000 In-kind Support Anticipated
- \$50,000 Other (Federal Agency) Support Anticipated
- \$50,000 Other (Industry) Support Anticipated
- \$2,544,000 Total Estimated Budget

Budget Justification

The proposed budget is based on making continued critical investments in research-support activities that address the agricultural, 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 is the first budget to fully incorporate the NRSP9's Strategic Plan, with designated milestones, performance measures, and specific deliverables to ensure accountability for the investment.

A modest increase of \$50,000 in the proposed budget over the previous project budget reflects priorities that have been requested by stakeholders. A cost-effective strategy has been proven over the past 5 years with the establishment of NRSP-9 and its initial focus on four major agricultural species. Incorporating and building on this strategy, the project now needs to be responsive to stakeholders by incorporating several other important species—aquaculture, small ruminants, and horses—allowing for more comprehensive information to fill gaps that will enhance the current work. Including these three species does not represent a significant increase in budget because there are some similarities and

complementarity in feeds, models, and research approaches. It does require funds to cover the acquisition of additional data, resources, and committee members. Procuring and incorporating data and resources for these three additional species will result in increased website maintenance and data management costs. Travel costs are also expected to increase as new members are added to provide requisite expertise in these areas.

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. A web development company has 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. 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 webpage as outlined in the contract with the web development company hosting the page. Funds are also requested to support travel of the Feed and Ingredient Composition Committee and the Modeling Committee members to regular meetings of their committees for development of the research support materials and models.

See attachments 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 and distributions will be revised, if necessary, by the Program Leader and the

four Regional Administrative Advisors. A portion of the funding will be allotted to the institution of the Feed Composition and Modeling committees (\$28,000 per committee). 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.

NRSP-9's Contribution	Value	Leverage	Partners ^a
Feed composition information on 1,497,863 samples	1,497,863 samples x \$10/sample = \$14,978,630	Information made publicly accessible represents over \$14.9 million in analytical costs if analyses were conducted and paid for by individuals.	Industry (private, for-profit) National Research Council (private, non-profit)
NRC Dairy (2001) and NRC Swine (2012) data recovered and preserved	\$240,000 ^b	Preservation of the NRC datasets represent approximately 6,000 research hours each.	National Research Council (private, non-profit)
Research support to national beef nutrition efforts	\$300,000	Research support to the NRC efforts helped leverage \$300,000 in sponsor support to establish nutrient requirements of beef cattle for use by researchers.	American Feed Industry Foundation (IFEEDER, non-profit foundation) National Research Council (private, non-profit)
Research support to national dairy nutrition efforts	\$300,000	Research support to the NRC 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).
Research support to general animal nutrition efforts	\$25,000	Research support provided to the NRC helped leverage support from other federal agencies for animal nutrition research activities.	Food and Drug Administration (government)
Research support to published animal nutrition model software	\$40,000	Research support provided to the nutrition community represents over \$40,000 in modeling technology software updates if paid for by individuals.	N/A

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

^bEstimate based on average wage of \$40/h for 3 years of 10 researchers working 0.5 days per week on NRC data collection. Costs of running experiments were not included

The funds leveraged by NRSP-9 to support animal-nutrition research are significant. A total investment of \$875,000 over the initial 5-year NRSP-9 project period has helped leverage additional resources valued at \$15,883,000 resulting in a total of \$16,758,000 available to support NRSP-related national animal nutrition research effort – a sum that is 19 times the original NRSP investment.

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 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 original 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 in the online feedback forum is also critical to the involvement of stakeholders in NRSP-9 research support activities. 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. 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 its 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 and quality of publications (e.g. citation index) is a common measure of both research support accomplishments and outreach efforts to the community.

Members of NRSP-9 also evaluate the accomplishments and impacts of the research support by monitoring stakeholder usage of these different website components. By relying on stakeholder usage metrics, NRSP-9 members get a more accurate, more authentic understanding of the usefulness of

different research support approaches. Metrics like visits, visitors, and pageviews help assess the magnitude of use while metrics like average time per visit and pages per visit help determine the quality of user experience. Users who find value in a page divert more of their time to that resource. Location use statistics help identify the global impacts of NRSP-9 and the proportion of new users helps to identify saturation of NRSP-9 utility within the stakeholder community. Continued monitoring and evaluation of these metrics help NRSP-9 members identify key areas of focus within the site that users find valuable and therefore can help identify relative impacts of these elements.

Developing Communication

The original NRSP-9 proposal listed several potential methods that would be adopted to communicate updates and research support activities to stakeholders. These included: public meetings, workshops, web conferencing, webinars, on-line dialogues, email conferences and 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. 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.

In addition, NRSP-9 is developing a 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 mechanism used by NRSP-9 is the website and the material therein. Results are also shared at professional society meetings and through the annual and midterm reports available online. 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, 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.

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 renovation of the Dairy and Beef NRC software platforms to run on modern computers; release of 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 summer of 2014, the Dairy and Beef NRC pages on the website were visited an average of 6.5 times per day; the feed database was viewed an average of seven times per day; animal performance data was viewed once daily; and the modeling and statistics resources organized and summarized on the website was viewed twice daily.

Future Additions

The planned expansion of focus to include aquaculture species, small ruminants, and horses will result in a wider audience, additionally including stakeholders interested specifically in these species. As focus is expanded, new experts will be recruited to serve as committee members to appropriately represent the needs and interests of these new areas of focus. 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 will be in place, 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, listening sessions, and formal needs assessments or surveys.