NEBRASKA INTEGRATED BEEF SYSTEMS

SHAPING THE FUTURE OF THE BEEF INDUSTRY

Nebraska is the epicenter of beef production in the United States and a world leader in the global beef industry. First in red meat production, first in commercial cattle harvest, second in cattle and calves, second in cattle on feed – there is good reason Nebraska is known as the Beef State.[1] The unique combination of forage and water supply, crop and ethanol production, and feeding and packing infrastructure make Nebraska a world leader in beef production. Leaders of the Institute of Agriculture and Natural Resources (IANR) at the University of Nebraska-Lincoln (UNL) have determined that the red meat industry, with the tremendous demand an ever-increasing world population places upon it, is a healthy future growth area for Nebraska and IANR. Nebraska is known for the excellence of our beef, and the excellence of those who work in beef research, teaching, and extension at UNL. Across IANR, our faculty and extension educators reflect excellence in beef research, environmental sustainability, resilience of working landscapes, antimicrobial resistance, animal health, food safety, and well-being of animals and people. Research, teaching, and extension are the three intertwined missions of Nebraska's flagship land-grant university. All three are priorities, contributing to the education of students, our future industry leaders. Developing future leaders will affect the sustainability of food production needed to feed the increasing global population, which affects all of humankind. In addition, it is a point of pride that IANR does exceptionally well at translating basic research outcomes to constituents so Nebraskans can quickly gain and put new knowledge to work in their businesses and lives. A thriving, innovative beef industry is a definite part of growing a healthy future for Nebraska and the world, and we are dedicated to that growth.

With broad capacity across research, teaching, and extension, UNL is in a unique position to leverage and amplify existing and new systemwide facilities, infrastructure, and personnel into a world-class program in integrated beef systems. UNL is poised to become the nation's — and the world's — leader for beef production excellence. To focus on that goal, IANR created the **Nebraska Integrated Beef Systems (NIBS)** platform.

INTRODUCING NEBRASKA INTEGRATED BEEF SYSTEMS

The state of Nebraska and UNL are uniquely equipped to lead the development of resilient, integrated systems for the production and delivery of nutritious, high-quality beef. There is no place in the world, no university in the world, better positioned to effectively address this grand and complex challenge. Our faculty and beef educator expertise and the expertise of our partners at the U.S. Meat Animal Research Center (USMARC), the capacity and diversity of our state-wide infrastructure for supporting discovery, translation and the delivery of solutions, and the breadth and strength of our stakeholder networks across an industry that contributes over $12 billion annually to the state's economy, represent an unparalleled connection of the range of resources that will be required.

The vision for NIBS is "to create knowledge of alternative systems for efficient and sustainable beef production through integrated and transdisciplinary research efforts and to deliver information and tools based on that knowledge through formal student training and extension activities, enabling more informed decisions." This vision builds on more than a century of excellence in beef programs at UNL and pushes the scope to include studies that integrate cropping systems, grasslands, resilience of working landscapes, and rural community prosperity. It leverages a genomic discovery engine created in partnership with our colleagues at USMARC, and UNL's Research, Extension, and Education

Centers (REEC) and associated satellite facilities located across the state, to provide a platform that can be applied by our faculty teams to study virtually any novel and valuable trait. The figure below depicts one example trait (Bovine Respiratory Disease) and the range of tools and impacts that are possible through the NIBS statewide platform.
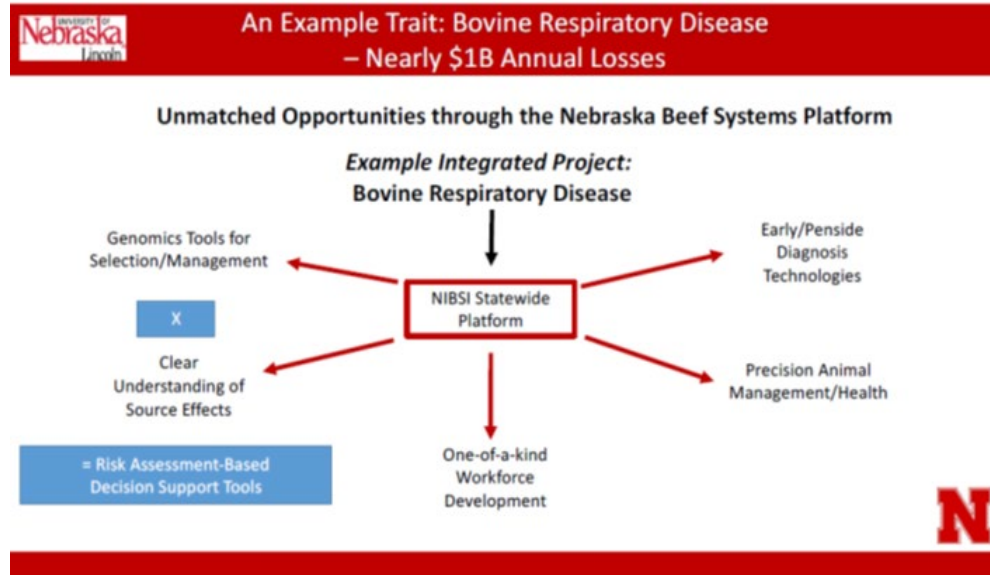

NIBS brings together a collaborative team of faculty across IANR and provides students opportunities for training and research that can't be found anywhere else. Through the NIBS platform, UNL can capitalize on its resources and strategically invest in the future to become the undisputed thought leader in the beef industry. **The time is now for Nebraska** to become the best place in the world to learn, research, and experience the future of beef production systems.

NIBS GUIDING PRINCIPLES

Beef systems cut across all segments of the industry acknowledging the interacting effects of genetic potential of cattle with varying production environments and management practices and recognizing consumer attitudes toward the environment, animal well-being and health, and their desire for heathy, nutritious, and safe animal protein products. Therefore, guiding principles begin with an emphasis on Genetics × Environment × Management × Societal concerns (GEMS) in the design of projects. Adoption of this approach recognizes the importance of interaction between elements of GEMS. Knowledge of these interactions will lead to a more precise decision-making process for individuals engaged in all aspects of beef production.

- G = Genetic - There are levels of genetic contributions that can be evaluated in the GEMS approach. These include comparison of breeds across the other elements of GEMS, comparison of sires across the other elements of GEMS, and at the genomic level comparison of genotypes of variants across the other elements of GEMS. Genetic selection will continue to evolve as understanding of how genotype interacts with management, environmental and societal goals to results in desired cattle phenotypes is refined.

- E = Environment - UNL has multiple REECs across Nebraska that are located in differing environments (see Map below). This dispersion of facilities supports the efforts in addressing GEMS by providing for expression of phenotypes in differing environmental settings. Environment continues to present unique challenges for the future of the beef industry. For example, annual loss of 60 square miles of range and pasture resources due to eastern redcedar encroachment is a thorny challenge. Efforts to further concentrate beef systems in Nebraska should recognize and avoid the environmental failures that have occurred with regional concentrations of other animal species (e.g., pork production in North Carolina). In addition, supply chain-led sustainability initiatives will require future investments in our understanding of environmental issues such as greenhouse gas emissions as well as our traditional Nebraska water quality and odor/dust concerns.

University of Nebraska - Lincoln Institute of Agriculture and Natural Resources Facilities
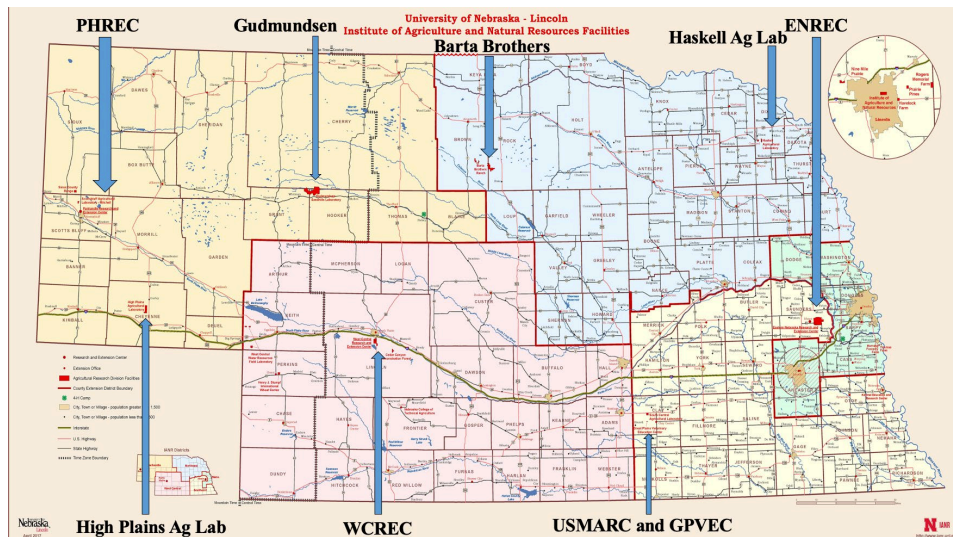
- M = Management - UNL has numerous studies in differing management systems across multiple disciplines. Under the GEMS concept these studies will consider addressing one or more of the interactions within GEMS. Management and associated profitability opportunities will continue as important to the Nebraska beef industry's future. However, significant shifts are expected. For example, a shift from the current focus from disease management with antimicrobials to a focus on disease prevention will be essential to productivity and profitability as well as an expectation of consumers. Also anticipated is a shift in cow production from grass-based systems to strategic use of limited grass acres, off season forage production from cropland, and confinement of cows. Feedlot innovation will need to consider alternative housing systems as well as uses of technologies for individually managing animal performance. Finally, beef systems will continue to be driven by economic challenges with a focus on comprehensive risk management, farm succession, and policy in addition to our traditional financial solvency challenges.

- S = Societal - Societal opportunities and challenges will have substantial impact on the beef industry's future, many of which are just now developing. Consumer expectations for a safe and sustainable production of food will set expectations for the beef industry, some of which will present unique challenges and discomfort for the industry. Consumer expectations are driving the establishment of supply chain initiatives to define sustainability, information sharing networks to give value to products meeting consumer expectations, and alternative strategies for managing beef production and animal health and welfare. Forward looking research and extension programs will integrate the expectations of consumers in determining "success" for Nebraska's beef industry. NIBS partitions the societal component of GEMS into three categories:

i. Product – production agriculture interacts directly with society via the product produced. Society desires a nutritious, affordable, and safe product.
ii. Rural culture – long-term sustainability of beef production must be economically viable to support both the producer and the local infrastructure in our rural communities, and those communities are at risk due to shortages of labor and challenges associated with bringing new or young producers back to farms and ranches.
iii. Societal concerns – societal concerns regarding agricultural production practices and impacts on animal welfare and the environment call into question the viability of agriculture's social license to operate.

Emphasis on the Understanding Genotype to Phenotype

Understanding the cascade of events from the translation of DNA to the expression of a phenotype will be central to future selection and management protocols for beef cattle production. The genome of an individual is set but influencing the cascade of events from the translation of the genome forward through alternative management strategies is fertile ground. This is analogous to individualized medicine and lifestyle recommendations sought in human genome research. This guiding principle is patterned after the USDA Blueprint for Animal Genome Research (2019).[2]

Emphasis on the use of precision management tools

The concept of precision management in the context of beef systems is to use technology to monitor individual animals in group settings. Advancement will allow for the management of livestock health and production using the principles and technology of process engineering to monitor, model, and manage beef cattle. This 'per animal' approach is aimed at optimizing health and performance of the livestock system by optimizing health and performance of individuals within the group.

All animal phenotypes across projects will be migrated to a central database

Numerous projects across disciplines are accomplished on beef animals within the UNL system. Data from these projects are typically housed in individual scientist computers. Centralizing the information from these experiments will allow for coordination of research into the relationship of observations taken on the experimental units throughout the animal's life and provide the opportunity for comprehensive analyses.

Emphasis on the value of information flowing across segments of the industry

The beef industry is segmented. Unless the cattle are in a vertically integrated system, animals (and products derived from them) change ownership potentially multiple times. Typically, knowledge of attributes (management and genetic) does not flow with the individuals. There is potential value in information obtained within each segment to subsequent owners. Determining the value of that information is central in incentivizing the industry to develop systems for the exchange of information.

Industry partnerships will be created to support translational research projects

UNL has a large number of beef animals under control. However, the opportunity always exists to create partnerships to accomplish field or on-farm studies necessary to demonstrate application to speed up adoption of knowledge or technology. UNL has a cadre of beef extension educators that can be instrumental in helping to form and nurture these projects.

Animal health and welfare

Animal health is central to the economic viability of the beef industry. Enormous costs are associated with diseases such as Bovine Respiratory Disease. Regulations on the use of antibiotics increases the importance of developing management strategies to mitigate risk of disease and in developing genomic tools to select animals with increased resistance or tolerance.

Consumer acceptance (social and product)

Ultimately, the viability of the industry rests on the continued acceptance of the product produced. Beyond the issues of a healthy, affordable, and safe product exists a growing interest and concern for how the product is produced and how resources allocated to the production of the product are used. The latter concerns need to be addressed by developing systems that optimize animal well-being and resource consumption and to provide the public with knowledge of those systems.

ENVISIONING FUTURE OPPORTUNITIES AND CHALLENGES FOR THE BEEF INDUSTRY

**Achieving Sustainability within the Beef Supply Chain**

Sustainability has three components: economic, environmental, and social. For the industry to be sustainable will require that producers are compensated for their investment in production of beef, that strategies be designed to insure optimal use of resources used in production, and that the consumer has confidence in the product being produced (healthy and safe). Sustainability will also be enhanced through effective workforce development to include creating an environment conducive to enticing people into the industry and continuing education to nurture those already in the industry. Food supply chain groups such as the US Roundtable for Sustainable Beef (USRSB) have taken the lead on defining and implementation of sustainability for commodities such as beef. It is critical that UNL, using the NIBS platform, be a part of this conversation to insure a role for science-based information in the decision-making process.

Short term investment: UNL has faculty willing to: 1) invest in sustainability conversations; and 2) develop and deliver the educational resources targeting sustainability in beef systems based, in part, on the indicators of USRSB, National Cattlemen's Beef Association, Beef Alliance, allied industry partners, etc..

Long term investment: UNL has faculty willing to lead research outcomes targeting beef industry sustainability challenges such as greenhouse gas emission reduction and alternative strategies for improving system efficiencies.

Industry Challenge

The food supply chain is making significant investment to ensure that their customers/clients view their contribution to the supply chain as contributing to sustainability. They are also asking challenging questions about the sustainability of their upstream suppliers of inputs. An example is a company such as McDonalds investing in reduced energy and greenhouse gas reduction both by their vast network of retail outlets as well as their engagement of the supply chain for beef to encourage a smaller greenhouse gas footprint.

Members of USRSB (Fall 2017)
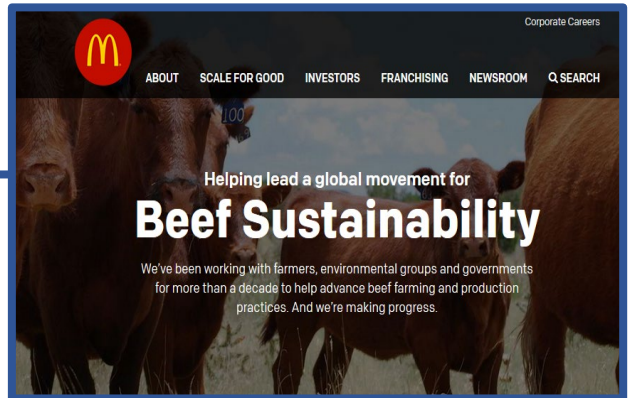
USRSB[3] is a consortium that has formed out of a shared interest of companies such as McDonalds to advance, support, and communicate continuous improvement in sustainability of the U.S. beef value chain. This organization intends to collectively define the term "sustainability" and how it is applied to all sectors of the beef supply chain. The consortium of 100+ organizations represents the sectors associated production, allied industry, packers/processors, retail/food service, and civil society. UNL is a member of this consortium and faculty represent our missions.

This organization has currently identified six indicators of sustainability including: 1) animal health and well-being; 2) efficiency and yield; 3) water resources; 4) land resources (generational transfer and grazing management); 5) air and greenhouse gas emissions; and 6) employee safety. USRSB members have agreed upon metrics for measuring sustainability as applied to the cow-calf, feedlot, sale barn, processing, and retail sectors of the supply chain. Procedures for assessing and measuring these indicators and piloting implementation/education programs designed to apply sustainability concepts are underway.

The next generation of research and educational efforts for land grant universities will need to connect with and provide leadership towards sustainability efforts to insure the relevancy of our research, education, and extension functions. NIBS will:
- Provide resident education to develop the relevant sustainability knowledge/skill sets for students being employed by these industries;
- Provide research programs to support sustainability challenges facing the beef industry including those defined by both traditional beef industry organizations as well as a beef supply chain initiative;

- Deliver Extension programs with goals of producing continuous improvements for beef production and processing sectors.

NIBS GOALS TOWARDS SUSTAINABILITY OF BEEF SYSTEMS

The goals of NIBS involve optimization of Nebraska beef production in an economically, socially, and environmentally sustainable manner (see figure below). With the help of strategic partners both within and outside of IANR, we will: 1) develop and support implementation of Nebraska beef systems that optimize feed resource use, natural resource conservation, and producer success; 2) create knowledge of alternative systems for efficient, profitable and sustainable beef production through integrated and interdisciplinary research efforts; 3) deliver information and tools based on created knowledge through formal student training and extension activities enabling more informed decisions; 4) increase animal fitness and improve animal welfare; and 5) meet consumer needs and desire for nutritious and flavorful animal protein. Increased knowledge of GEMS will lead to commercial implementation of genomic technology resulting in accelerated genetic improvement and decreased animal disease. Translated research will lead to improved upcycling of rangeland, pastures, crop residues, annual forages, ethanol co-products, and cover crops with the goal of carbon neutrality and improved water usage. Our priorities align with industry partners to improve water and land resources, decrease air and greenhouse gas emissions, enhance efficiency and yield, improve animal health and welfare, and a highly trained workforce.
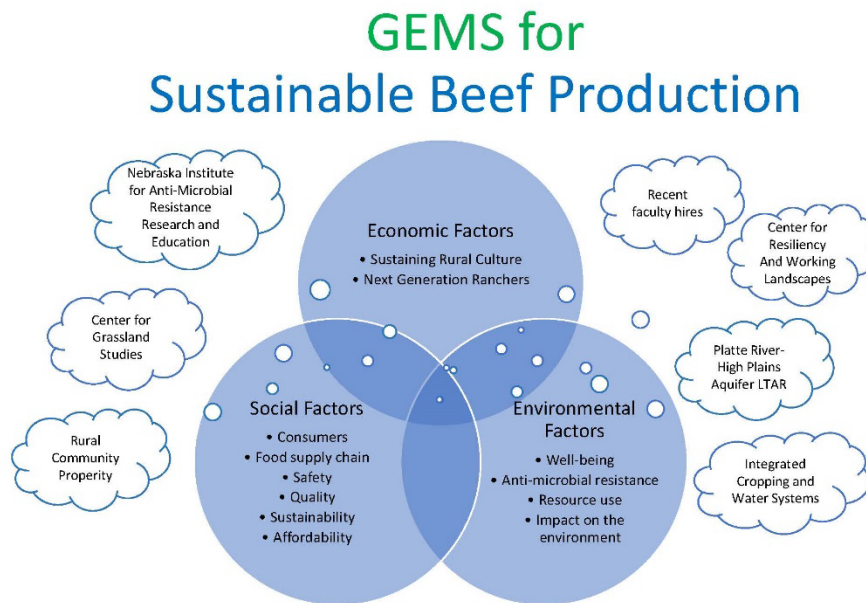

NCBA, *Agriculture Groups Launch Farmers for a Sustainable Future to Highlight Environmental Stewardship*, NCBA.org, Feb. 19, 2020

COMMITMENT OF RESOURCES TO SUPPORT NIBS GUIDING PRINCIPLES AND CHALLENGES/OPPORTUNITES

In 2017, faculty in IANR and USMARC established a five-year plan with the goal to develop and support implementation of beef production systems that optimize feed resource use, natural resource conservation,

and producer success in Nebraska through improved management of perennial grasslands and systems of integrated crop-beef cattle production. This multidisciplinary team of scholars is comparing traditional, segregated crop and cattle production to systems that integrate grain crop and beef production and to evaluate the impact of integrated systems on crop and cattle production, soil quality, and economic viability. The overarching goal is to develop and support implementation of beef production systems that optimize the use of land, cattle, and human resources through management strategies that enhance producer net returns and sustains soil health and other ecosystem services (see figure below). The focus is on producer success and natural resource conservation through management of perennial grasslands and systems of integrated crop-beef cattle production.
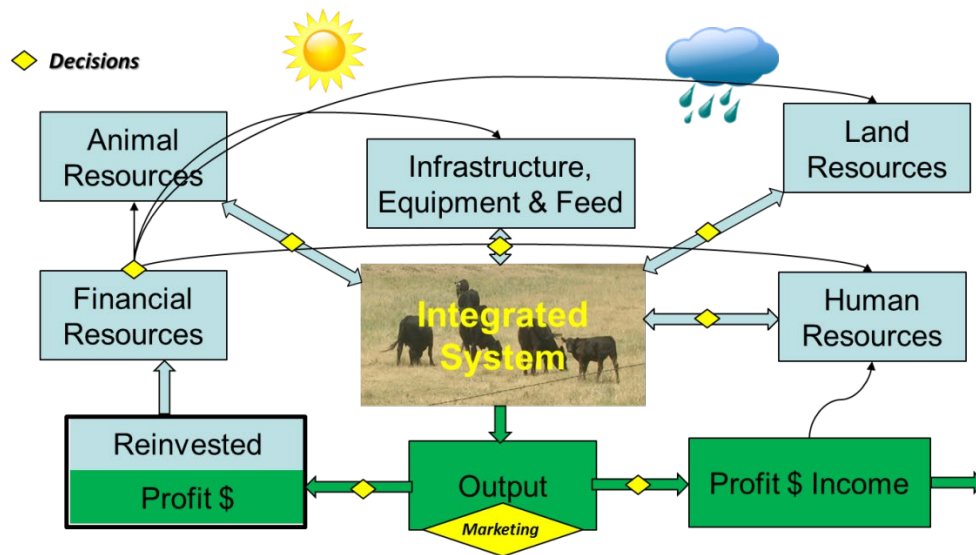
This Integrated Beef Systems plan involves faculty from several departments across IANR, scientists at USMARC, and beef educators from across the state of Nebraska.

During planning and development of the guiding principle for NIBS, several gaps were identified which needed to be filled in order for UNL to provide leadership towards integrated beef systems and sustainability. As a result, IANR has filled three key faculty positions in the School of Veterinary Medicine and Biomedical Sciences. These faculty are located at the Great Plains Veterinary Educational Center (GPVEC) at USMARC, Clay Center, NE and have expertise in clinical and animal health teaching, research, and extension. Additional faculty (5) with expertise in animal behavior and welfare, beef quality assurance, cow/calf management, feedlot nutrition, and precision livestock management have also been hired. We also have expertise across IANR that builds out incredible strength in areas related to NIBS (add faculty and educator list in Appendix).


KEY IANR PARTNERSHIPS ON THE NIBS PLATFORM

The faculty and staff of IANR at UNL continue to lead transdisciplinary approaches to develop the resilient food production systems essential to a nutrition and natural resource secure future for the world. Within that broad mission and the many systems-based efforts underway at Nebraska, we have tremendous capacity across research, teaching and extension for integrated, science-based innovation in development of resilient systems for food animal production, health and well-being. Our integrated programming in Integrated Beef Systems builds from a base and history of more conventional research

and development to include new technologies and an expanding scope in precision livestock management and health.

State-wide Research, Extension, and Education Centers and Partners

IANR manages over 40K acres of university property strategically located across the state of Nebraska and anchored by Research, Extension, and Education Centers at North Platte (WCREEC), Scottsbluff (PHREEC), and NW of Lincoln (ENREEC). These centers and associated satellites create a unique network for leveraging the diversity of Nebraska's climates, production systems and communities to study interactions of GEMS. For example, existing research feedlots at ENREEC and PHREEC, and commercial-scale ranches at Barta Brothers (~6K acres) and the Gudmundsen Sandhill Laboratory (GSL; ~12K acres) provide a unique range of beef production environments for studies in NIBS. Plans exist for expanding these facilities with a new Feedlot Innovation Center at ENREC ($4.9M plan approved by the Board of Regents 9/2020) and a Ranch Innovation Center at Gudmundsen to enhance our discovery and development of new technologies, partnerships with the private-sector, and education and training of students at all levels. Our long-standing partnership with USMARC adds another level to infrastructure capacity for integrated research and education with ~35K acres, ~8K cow/calf pairs, ~3k sheep and ~700 litters of swine per year. The facilities of GPVEC, which is located at USMARC, includes a 16K ft^2 facility containing surgery, clinical, laboratory, classroom and office space, and dormitory rooms accommodating up to 24 occupants.
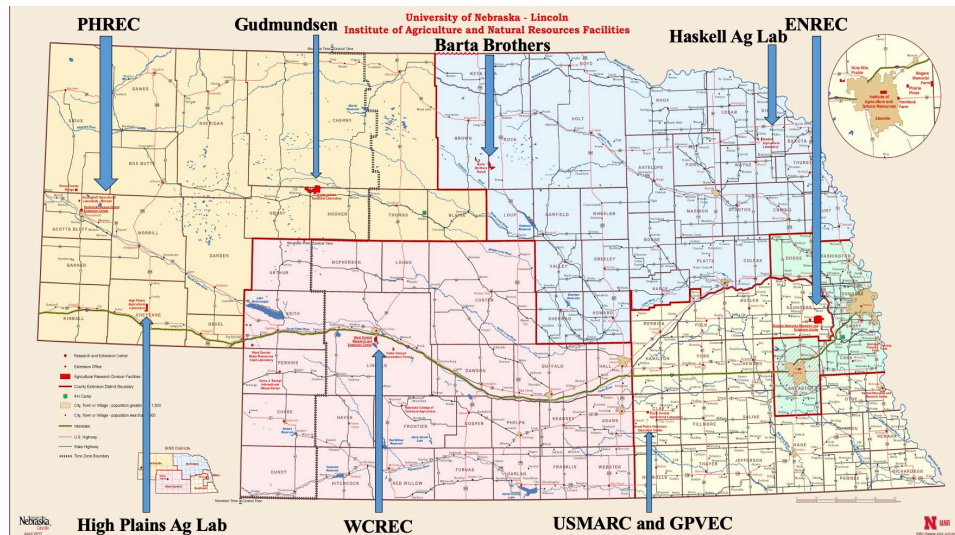
The National Institute for Antimicrobial Resistance Research and Education
(https://www.niamrre.org/)

The National Institute for Antimicrobial Resistance Research and Education (NIAMRRE) was founded in 2018 by the UNL, Iowa State University, the University of Nebraska Medical Center and the University of Iowa Medical College through a national competition sponsored by the Association of Public and Land Grant Universities (APLU) and the Association of American Veterinary Medical Colleges (AAVMC) to convene a One Health approach towards solutions for antimicrobial resistance (Healthy Animals, Healthy Humans, Healthy Environment). NIAMRRE builds on research at UNL, and including collaborations with USMARC, studies the dynamics of antimicrobial use and resistance in livestock production systems and surrounding landscapes. The first two themes outlined in the NIAMRRE proposal relate directly to priority areas emphasized in our foundational programs and in NIBS, and provides another local vehicle for enhancing our impacts in the animal health space:

1. **Reducing antimicrobial use by adapting precision agriculture and antibiotic alternative approaches to animal agriculture management.**

   - Development of Antibiotic Alternatives – focused on alternative approaches to antibiotics including immunomodulators, pre/probiotics, altered nutrition.
   - Improving disease detection and mitigation – focused on development of new sensing systems to detect sick animals, improved facility design to allow rapid isolation of sick animals and development of novel biosecurity measures prevent spread once disease is identified.
   - Improving disease prevention and treatment – focused on decreased disease burden through improved facility design, genomic selection for disease resistance, use of novel PK/PD modeling efforts to improve treatment success while minimizing development of resistance.

2. **Improving clinical decision making related to antibiotics by development of innovative, rapid and clinically translatable diagnostic testing platforms (pen-side/point of care).**

Center for Resilience in Working Agricultural Landscapes
Agricultural production must increase more than 70% by 2050 to meet the global demand for food, fuel, feed and fiber. Meeting this goal will require far-reaching growth in agriculture, more efficient use of marginal lands and new methods to deal with extreme weather, soil degradation and biological invasions. Strategies for achieving these advances while preserving Nebraska's healthy agricultural ecosystems is the goal of the newly formed Center for Resilience in Working Agricultural Landscapes (CRAWL). One proposal involves an adaptive management research approach for evaluating management strategies designed to achieve multiple ecosystem services on private rangeland (grazing lands) in the Sandhills and assess tradeoffs amongst suites of services. A primary goal is to determine if grazing management can be implemented in a manner to achieve livestock production and conservation (including wildlife habitat, recreation, and watershed) goals. We have expertise and established programs in adaptive management in CRAWL and SNR. Adaptive management research is being implemented at other sites to test how rangelands can be best managed for multiple uses/purposes (https://www.ars.usda.gov/plains-area/fort-collins-co/center-for-agricultural-resources-research/rangeland-resources-systems-research/docs/range/adaptive-grazing-management/; https://www.uidaho.edu/research/entities/rock-creek/about). Stakeholders (e.g., ranchers, state and federal agencies, conservation organizations, non-governmental organizations) meet together several times each year and are integrally involved in designing, implementing, and monitoring programs. Stakeholders learning from each other and making evidence-based decisions and conclusions is a critical part of the process and is documented to provide continual improvement in the process of developing collaborative groups.

Center for Grassland Studies
The Center for Grassland Studies provides focused, interdisciplinary research, education, and service programs and activities that emphasize the role of grasslands as the natural resource and forage base for a diversity of ecosystem services, including livestock production, wildlife habitat, and turfs. The Center is home to two undergraduate degree programs, PGA Golf Management and Grassland Systems, and hosts the annual Fall Seminar Series and the Nebraska Grazing Conference. The Center also administers the management of University of Nebraska-Lincoln prairies, such as Nine-Mile Prairie, and provides an administrative platform for trans-disciplinary integrated beef systems research, extension, and education.

Platte River – High Plains Aquifer
The Platte River – High Plains Aquifer (PR-HPA) is one of 18 sites in the Long-Term Agroecosystem Research (LTAR) network across the US. PR-HPA is a partnership between IANR at UNL, the USDA-

ARS Agroecosystem Management Research Unit (AMRU) in Lincoln, and the USDA-ARS Environmental Management Research Unit (EMRU) in Clay Center, NE. The PR-HPA network encompasses 27,750 ha of research sites with data going back to the early 1900s. A partial list of on-going research projects include: long-term manuring and continuous corn (Est. 1912); dryland tillage plots (Est. 1970); soil nutrients and tillage (Est. 1983); biofuel feedstock studies (Est. 2001); and carbon sequestration study (Est. 2000).

NIBS Action Plan

Implementing a comprehensive genomics program

All animals in the UNL system (cows, bulls, calves, steers, heifers) will be SNP genotyped. Currently UNL owns and manages multiple herds across the state. In many cases, sires of the animals produced within this system are not known. This precludes the ability to perform genetic studies on observations collected on those animals. The use of SNP assays will allow for parentage determination and for further Genome Wide Association Studies using phenotypes generated in experiments using these animals.

Currently calves used in populating the feedlots within the UNL system are obtained from herds within UNL and supplemented by purchasing calves from sale barns. Going forward, calves purchased outside the UNL system will be sourced where possible from large cooperator herds. These herds will be collaborators in the genomics program and instrumental in demonstration projects.

Developing capacity to collect phenotypes across environments

An essential component of studying $G \times E$ is the ability to replicate data collection of animals of known genetics in different environments. We collect data from cattle in both pasture and feedlot settings in order to contribute to the precision management effort on ranches and feedlots.

In the pasture setting we are implementing use of equipment (Super SmartFeed Systems) to allow for different supplementation strategies allowing for $G \times M$ studies locally and also to distribute this equipment at the PHREEC, GSL, and at the Barta Brothers Ranch to enable $G \times M \times E$.

In the feedlot setting we are increasing our capability in collecting feed intake data at both the PHREEC and ENREEC. Feed costs are a significant component in profitability and studies of strategies to lower this cost are needed especially in the development and assessment of new feed resources.

Cattle coming into the UNL feedlots will have been exposed to different management strategies. Some will enter the feedlot as weaned calves and others will be backgrounded on either pasture or crop residues and alternative crops in two crop systems as is being studied currently in the 5-year beef systems project.

Developing a Feedlot Innovation Center

To develop and apply technology for precision management will require a facility that is designed to accommodate the use of that technology. We refer to that facility as the Feedyard Innovation Center being developed at ENREEC. This feedyard will have open pens of commercial scale and a deep bedded barn structure allowing for the study of management strategies in two local environments enabling $G \times M \times E$ studies. Animals going through this facility will be deeply phenotyped before and during their stay at the facility and at harvest. Students will be engaged in the management of the facility through a semester long internship providing them with experience in animal care and in new technologies.

To create and evaluate emerging technology used in the management of animals in feedlot settings, NIBS seeks to upgrade existing research facilities at ENREEC and build capacity for research by investing in new equipment and people.

The Feedlot Innovation Center at ENREEC will allow for:

- Commercial-scale research;

    - 18 pens in open lots – 60 head per pen

    - 18 confinement pens – 60 head per pen

- Innovative facility designs to test innovations that improve welfare, nutrient management, health and performance;

- Student training with the latest technology; and

- Development of precision management tools, including an individual feed intake capacity system.

An updated facility with commercial-sized pens will allow UNL faculty to create and test new precision management technologies that can then be implemented by the industry. The Feedlot Innovation Center will also ensure the next generation of feedlot professionals have the opportunity to train in a commercial feedlot setting with cutting-edge technology. Also, extension programming and research demonstrations can be held in an environment that closely replicates a setting familiar to industry partners.

The total cost for the feedlot is roughly $4.9 million. A shop/education center (estimated cost of $1-$2 million) and renovations to the feed mill (estimated cost of $1-$2 million) will complete the project at an estimated cost of $8-$10 million.

Developing a Ranch Innovation Center

The Ranch Innovation Center aims to achieve more productive, efficient, and sustainable ranching operations based on utilization of technology-based tools to optimize resource use and production outputs. The proposed plan for the Ranch Innovation Center is based on real-time monitoring from cattle performance to environmental conditions. Individual animal management will be utilized with smart, precision feeding technology with animal weighing capacity at a pasture level to decrease cost of labor and optimize individual animal performance. Understanding individual animal performance instead of group performance will allow for greater ability for selection and understanding of variables that contribute to greater efficiency and adaptability to climate change or drought. Overall, this will create a more secure supply of high-quality protein for human consumption derived from feedstuffs unusable by humans. Infrastructure at GSL will be enhanced to take on challenges faced by livestock producers. Enhanced infrastructure at GSL will include cross-fencing pastures, two working/weighing facilities, and high-speed, wireless internet across the ranch.

Ecosystem services need to be monitored, evaluated, and documented within the context of sustainable beef production under different management systems. More precise monitoring sensors that can capture variability in weather, soil water and nutrient cycling, vegetation dynamics, and individual animal grazing behavior will aid scientists in better linking interactions and potential tradeoffs between livestock production and other ecosystem services. Continuous measures as an ongoing part of the sustainable infrastructure of the ranch of the future will monitor and understand cattle grazing on rangeland

ecosystems to then better be able to create treatments to improve climate change antidotes, greenhouse gas production, heterogeneity and biodiversity of landscapes, and carbon sequestration. Understanding these systems will provide greater opportunities to enhance management for a greater suite of benefits derived from grazing lands.

The proposed Ranch Innovation Center will enhance the ability of our research to provide answers and solutions to problems that livestock producers face. In addition, it will allow for the development of selection tools for improvement in cow energy efficiency (either phenotype or genotype) and would enhance the profitability and the competitiveness of the U.S. beef industry. More efficient cows would also have other benefits by reducing nutrients excreted into the environment, possibly changing greenhouse gases produced, and reducing the need for supplemental feeds and forages. Overall, the expected outcomes of the Ranch Innovation Center are focused on improvements in resource management (environmental and animal), community vitality, and animal health and welfare.

The transformational impacts and outputs these technologies will have in grazing livestock systems include:

- Enabling more informed and precision management
    - Decision support tools using precision data for livestock and grazing management

- Precision Management in Livestock Nutrition and Selection
    - Optimize the use of low-quality forages and use of extensive rangelands
    - Optimize precision nutritional supplementation delivery
    - Decreased labor and cost of production
    - Early detection of environmental stress on cow-calf production
    - Increased precision in matching cattle type to ranch operation goals
    - Increased resource use efficiency
    - Water intake and water site monitoring

- Detection or actual monitoring of grazing animal health status for earlier intervention

- Real-time monitoring of grazing land forage, soil, and environmental conditions
    - Increased rangeland utilization efficiency
    - Long-term monitoring of climate change antidotes
    - Data driven decisions for uncertainty in future drought or wet growing seasons

- Use of technology in rangeland management
    - Virtual fencing to manipulate cattle distribution
    - Use of GIS/GPS technology and drones/satellite imagery to improve rangeland and livestock management

- Measurement of novel or difficult-to-measure phenotypes or traits (e.g. feed efficiency on pasture, forage intake)
    - Increased selection for energy efficiency and resiliency of the beef cowherd

- Integrated and interdisciplinary systems approach research

- Increased student engagement and training

- Technology testing and training resource for livestock producers

As part of the Nebraska Integrated Beef System platform, a **Nebraska Ranch Management Program** will be developed to meet the need for management-level leaders in the ranching industry who will progressively manage Nebraska's rangeland and wildlife resources, produce livestock as part of our nation's food supply, and positively influence the lives of people on ranches and in ranching communities in Nebraska and the surrounding region. The vision is to educate leaders who will make a positive difference in ranching, rangeland, and natural resource management and meeting the needs for Ranch Managers in Nebraska and the surrounding region. The University of Nebraska Ranch Management Program will teach graduate students using a transdisciplinary, systems approach to ranch management, including range management (grass, grazing, and livestock production), wildlife management, and conservation. We will serve the ranching industry by empowering graduate students and other participants with skills that will enable them to strategically manage complex ranching operations and successfully lead our industry.

Expanding the scope of impact of the PHREEC feedlot program

The opportunity exists to have research at the PHREEC feedlot apply more broadly across the industry in the high plains. The feedlot industry has pointed out that research capacity has diminishing across the High Plains Region and suggested it is appropriate for UN to aggressively engage in this space. To accomplish this goal requires cutting edge feeding management at the PHREEC feedlot and to accommodate that in the long run requires a new feed mill and storage shed.

Rebuilding Meat Science

The University of Nebraska's Meat Science Program has a strong tradition and sustained expertise in research, teaching, and extension. Student education has been a focus. In addition, statewide extension education opportunities for meat industry personnel, extension educators, livestock producers, youth, and our consumers and serving as the source of meat science expertise for quality, safety, and regulatory compliance within Nebraska and beyond has been a focus. Basic and applied research is aimed at improving the quality, quantity, safety, nutrition, and value of meat and addressing meat and livestock industry needs.

Specific goals related to NIBS include:

- Increased consumer demand for beef and consumer confidence in product through enhanced quality.
- Examine healthfulness components of beef products related to GEMS.
- Expand knowledge in the areas of the metabolomics and proteomics in beef.

Given consumer questions about meat and the need to provide high-quality animal-sourced proteins to meet the increasing demands of a growing population, research opportunities abound with a focus on nutrition, quality, safety, and quantity. The opportunity exists to collaborate with food scientists, human nutritionists, engineers, and biochemists, among others, to bring an interdisciplinary focus to meat science research activities. Collectively, these efforts will support the grand challenge of sustainably producing beef and efficient use natural resources.

Recommendations for Meats Program:
1. Renovation of the current meat lab and slaughter facilities in Animal Science.
2. Improved capacity to phenotype meat products beyond standard quality measures via modern equipment particularly in the "omics" area.
3. Phenotypic data collection on high leveraged animals.

SUMMARY

UNL has all the elements needed to become the world's premier resource for beef cattle production through research, outreach, teaching and workforce development. This vision will be realized, providing the tools, resources and facilities needed to move the Nebraska beef industry forward through NIBS.

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Update
USRSB membership, 2020 Annual Report

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