STRATEGIC PLAN

Texas A&M AgriLife Research and Extension Center at Stephenville

Texas A&M AgriLife Research

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STRATEGIC PLAN: TEXAS A&M AGRILIFE RESEARCH AND EXTENSION CENTER AT STEPHENVILLE

Executive Summary

The Texas A&M AgriLife Research and Extension Center at Stephenville is in a different environment than most Centers as we are at the edge between rural and urban culture in the state, and we share appointments with Tarleton State University. The Stephenville Center is consistently adjusting to serve the needs of our stakeholders in the current environment. We are conducting this strategic planning process to better understand current personnel and facilities, to focus on needed changes/add/delete to better serve our clientele and research needs. The research priorities identified in this strategic plan aim to elevate AgriLife Research's impacts for all Texans and beyond, making AgriLife Research the most recognized national authority in agricultural, natural resource, and life sciences research.

This strategic plan is based on in-depth discussion with faculty and staff with analysis of Center strengths, weaknesses, opportunities, and threats (SWOT). We asked in depth questions related to each of these to ensure we analyzed our work from multiple perspectives. The SWOT analysis also included local and industry partners as well as key faculty and administration at Tarleton State University. In addition, we analyzed responses from our stakeholders related to our impact and importance. Finally, we used our collective responses to identify key issues that will impact on our work in the future. Directors from other Centers and associated department heads and agency directors also reviewed the draft plan and provided comments and suggestions. Revisions were made based on this feedback. After the reflective analysis, we participated in several sessions where we discussed the issues related to comprehensive analysis of AgriLife Research.

Informing Our Agency Strategic Plan

A strategic planning force of Texas A&M AgriLife Research Stephenville faculty and staff have guided the development of the following aspirational strategic plan for our Stephenville Research and Extension Center (STEP). The group reviewed AgriLife Research's strategic plan and considered them against input from a range of internal and external constituents.

Our faculty and several research staff developed an internal and external survey that informed a comprehensive analysis of the Stephenville Center. This strategic plan is based on in-depth discussion of center strengths, weaknesses, opportunities, and threats (SWOT).

The research priorities identified in this strategic plan aim to elevate the center's impacts for the agency, Texans and beyond, while ensuring STEP and Texas A&M AgriLife Research are the most recognized national authority in agricultural, natural resource, and life sciences research.

An adaptive strategic planning process has been implemented to detect and respond to variability across a broad scope spanning agricultural sectors, policy, environments, economies, and related impact areas over the next five years.

Strategic Planning

Strategic planning is a process that applies integrated information gathering in combination with available expertise, core funding, infrastructure, and responses to varying opportunities and challenges. It enables innovation, creativity, scientific excellence, and public service through inclusive leadership and teamwork.

Strategic planning can improve AgriLife Research's established research procedures and strategies by modifying traditional research management tactics, learning to adapt more intuitively, and considering the input of exceptional agricultural faculty and staff.

Effective strategic planning requires mechanisms that promote innovative ideas evaluated in an iterative or repetitive process, leading to continuous improvements in plans and delivered outcomes.

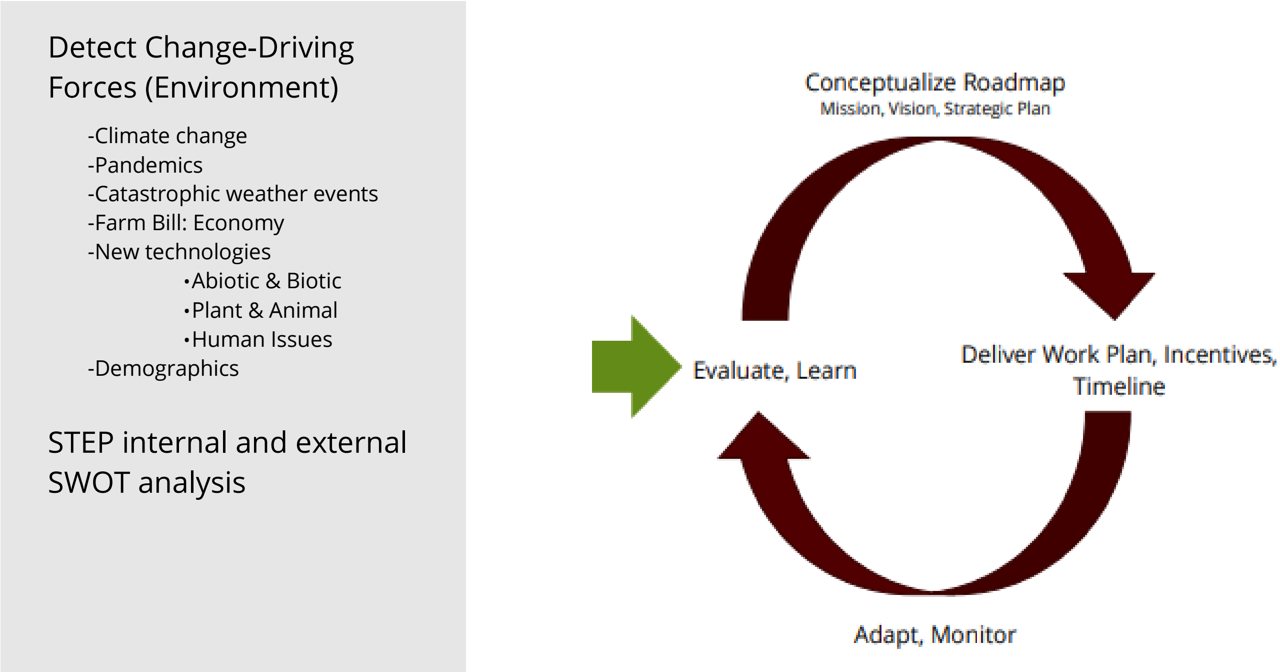


Figure 1. Dynamics and mechanisms of the proposed adaptive strategic plan

An adaptive strategic plan evaluates and responds to new relevant information with implications for STEP's portfolio (Figure 1). Our proposed mechanism includes:

- Invite innovative ideas and proposals for critical evaluation of potential outcomes and impacts using transparent metrics of success
- Develop executive summaries and define objectives, timetables, and incentives for meritorious proposals
- Adapt, monitor, and evaluate progress in gains made by STEP research portfolio arising from strategic plan and executive summaries
- Detect changes, learn, survey, and explore the environment to identify and gauge driving forces, adaptive methodologies and new technologies
- Identify and protect Intellectual Property (IP) when viable and leverage

BACKGROUND AND INTRODUCTION

Our Roadmap: Vision – Growing the Future

Texas A&M AgriLife at Stephenville will be recognized as a premier source of knowledge, outreach, research, and technology transfer to support the stakeholders of Texas in the North Central and District 8 Region. Our Strategic Plan outlined will guide the agencies and administrative entities of Texas A&M AgriLife as we formulate plans to conduct fundamental and applied research as well as develop and deliver Extension educational programs to help clientele achieve sustainable, environmentally aware, resource-efficient production systems. The STEP Strategic Plan is intended to guide research and education resource investments that address short- and long-term limitations facing the rural-urban interface in Erath County and the surrounding areas.

Vision

Facilitate healthy environment and humans through abundant, affordable, high-quality and sustainable food as well as access to clean natural resources and around the world while producing content innovation and new discoveries into new intellectual property (IP) and companies when justified.

Mission

- Develop an efficient and effective means of identifying priority research to benefit producers, industry organizations, stakeholders, and educational needs as well as strategies to address them;
- Encourage and support the formation of interdisciplinary research and extension teams organized around major industry and stakeholder needs and develop administrative support to ensure success;
- Serve as an internal guide for Texas A&M AgriLife administrators, research scientists, and extension educators concerning priorities for investment of resources and effort;
- Identify and develop proposals for potential funding sources to support personnel, research, equipment, and facilities to accomplish the priority Research and Extension program objectives.

Core Values

- Leadership
- Respect
- Loyalty
- Integrity
- Excellence
- Creativity
- Innovation
- Inclusiveness
- Accessibility
- Public service
- Responsiveness
- Agility
- Teamwork

These values reinforce STEP's commitment to delivering cutting-edge scientific tools, innovative solutions, and intellectual property for Texas producers, industry, and stakeholders in a rural-urban nexus. to support community well-being of all people. These efforts lead to the stability and continual enhancement of our regional agroecosystems and natural resources, further ensuring the economic competitiveness, sustainability and excellence of agriculture, natural resources, ecosystems, and human health.

Defining Strategic Priorities

STEP is working to find innovative solutions that will create adaptive agricultural systems — systems that can meet the demand of a growing population, changing climate, fluctuating economic conditions, unpredictable geopolitical environments, declining resources, and public health crises. Our strategic plan aims to make fundamental scientific discoveries and apply them to create new IP and technologies that will enhance the sustainability and resilience of adaptive agricultural systems. These efforts provide the translational research necessary for developing and producing high-quality, safe, and sustainable food and fiber systems with local, national, and global impact. These agile systems can meet the needs not only of food and fiber but also of clean water and air, functional landscapes, improved health and well-being, and the sustainability of resources for generations to come. This strategic plan includes the discovery, dissemination, and adoption of evidence-based research focused on the intersection the rural and urban nexus.

Strategic priorities are areas that STEP will emphasize over the coming years to make measurable progress toward enhancing the resilience of agricultural systems and ensuring innovative solutions to provide nutritious food, renewable energy, sustainable ecosystems for our citizens. After reviewing the vision and mission, evaluating the competitive advantages, and considering the context of the obstacles to sustainable systems, the following four broad priority areas include:

Priority One: Leading-Edge Research and Innovations - Sustainable Dairy Production and Ecosystems

Discover new innovations, technologies, and science-based solutions to enhance agricultural and ecological systems and the life sciences. Development of IP as warranted.

Dairy is an important industry, especially for North Central Texas. Our Center's research focuses on numerous aspects of dairy production, from forage production, cow nutrition, to environmental challenges.

About the Southwest Regional Dairy Center

The Southwest Regional Dairy Center (SWRDC) is the Texas A&M system wide dairy, administratively operated by Tarleton State University in Stephenville, TX. We work with a private producer (360 Ag) who rents the facilities from us, runs the day-to-day management of the cows, and permits herd use for teaching and research. Cows • 400 cows - Holstein, crossbred (mostly Holstein × Jersey), and Jersey • Cows milked 2X on 24-stall rotary o GEA

Rescounter II activity collars that ID into the parlor to track milk yield. o Composite sample collection at each stall on rotary. Free stall barns • Two free stall barns – deep bedded sand and rubber-filled mattresses with sand on top o Small barn – 47 head locks, 40 freestalls • Open pack with 47 headlocks o Large barn – 360 head locks, 264 free stalls • Gates to make 8 pens total (4 pens with 24 free stalls and 4 pens with 42 free stalls) • 48 calan gates, 48 free stalls • Small sand bedded open pack – three open packs, 40 headlocks Labs • Two functional labs at the SWRDC inside the atrium o Wet lab o Dry lab Equipment • Data ranger (with conveyor belt for easy loading) • 48 calan gates for individual feeding trials • SCR collars for heat detection, also record activity, and rumination time (located on every cow) • 100 Ice Robotics IceQube – measures lying and standing time, steps, motion, and lying bouts • 200 Ibuttons to measure vaginal temperature • 30 Hobo data loggers to measure ambient temperature and relative humidity • Weather station on sight and running • Palpation rail • Automatic sort gate in parlor exit.

The dairy utilizes a flush system with recycled effluent to clean the barn alleyways. Then the manure and effluent will run over a sand settling lane and ideally, the sand will settle to the bottom of the lane (this sand is recycled), the manure then flows through a static screen separator where manure solids are separated out, and then the manure will flow into a settling basin. Directly after the manure separator, recycled effluent is pumped to the silo that holds the effluent used for flushing. The manure solids stay in the pit and the effluent flows into the two-stage lagoon. The lagoon is clay lined. The effluent from the second stage is pumped to a pivot or traveling gun for irrigation 1) Acreage: Currently we have 426 total acres that we are permitted to apply manure and effluent on. 199 acres are on third party fields and the remaining 227 are on licensed management units. 2. Irrigation: We have 39 acres under pivot and 109 acres irrigated with a traveling gun for a total of 148 irrigable acres. 3. Equipment: For manure application, we utilize a H&S W3143 manure spreader pulled by a John Deere 6130M tractor. 4. Lagoon capacity: According to the documents back when the RCS was certified the total capacity is listed at 20.70 ac-ft. This converts to 6,745,125.64 gallons.

Sustainable Agroecosystems for Concentrated Dairy Production

One of our primary research projects integrates field, lab, and decision support tools to develop management strategies across animals, soils, crops, air, and water. When used and managed carefully, excreta from dairy concentrated animal feeding operations (CAFOs) provides a rich source of beneficial nutrients for agroecosystems through land application and other recycling pathways. However, the intensification associated with modern CAFOs is known to foster regional accumulation of reactive nitrogen and carbon, phosphorus, and pharmaceuticals exceeding the assimilative capacity of the surrounding agroecosystems. If not managed carefully, excess nutrients, antibiotics, and microbial pathogens may be released into air, water, and soil resources, degrading ecosystem functions through eutrophication, perturbed vegetative and wildlife communities, nitrate accumulation in drinking water, social nuisance conditions, and increased prevalence of antimicrobial-resistant pathogens. The predictable result of degraded ecosystem function is intensified regulatory and economic pressure, which raises the cost of production, thereby reducing the profitability and global competitiveness of the domestic livestock industry.

Our project integrates long-term field-scale experiments, laboratory analyses, and model development (a) to improve our mechanistic understanding of the fundamental fate, transport, and mitigation processes associated with ruminant-excreted phosphorus (P), reactive nitrogen species, carbon, fecal indicator bacteria, antibiotics, and antimicrobial-resistant pathogens released into the environment by (CAFOs) through soil, air, and water; and (b) to synthesize those process-based models into integrated modeling frameworks amenable to use in life-cycle and ecosystem-level assessments of sustainability consistent with the strategic aspirations of the beef and dairy industries in Texas and beyond. The project will also promote the adoption of priority management practices of well documented efficacy across croplands associated with beef and dairy CAFOs. The primary outcome will be the ability to assess and mitigate agroecosystem stresses imposed by concentrated, ruminant-livestock production systems through husbandry and feeding tactics, manure-application practices, ecosystem-monitoring techniques, and management practices across Texas' varied climatic, landscape, and livestock-production regimes. Those will ultimately provide guidelines for safe and sustainable manure application which will be highly beneficial to conservation programs.

When used and managed carefully, excreta from beef and dairy CAFOs provides a rich source of beneficial nutrients for agroecosystems through land application and other recycling pathways. However, the intensification associated with modern CAFOs is known to foster regional accumulation of reactive nitrogen and carbon, phosphorus, and pharmaceuticals exceeding the assimilative capacity of the surrounding agroecosystems. If not managed carefully, excess nutrients, antibiotics, and microbial pathogens may be released into air, water, and soil resources, degrading ecosystem functions through eutrophication, perturbed vegetative and wildlife communities, nitrate accumulation in drinking water, social nuisance conditions, and increased prevalence of antimicrobial-resistant pathogens. The predictable result of degraded ecosystem function is intensified regulatory and economic pressure, which raises the cost of production, thereby reducing the profitability and global competitiveness of the domestic livestock industry.

Reactive Nitrogen Species

Reactive nitrogen – which includes ammonia and its relatives, nitrogen oxides, and more complex, organic compounds – is an important player in a wide variety of ecological impairments such as high-nitrate drinking water, acid rain, respirable atmospheric aerosols, greenhouse-gas (GHG) accumulation, nuisance conditions, and loss of native plant and wildlife communities. Moreover, a significant proportion of the RNS that accumulates in agroecosystems derives from fossil fuels (especially methane) through the manufacture of nitrogen fertilizers. A significant gap exists in quantifying environmental effects of N, P, antibiotics, and pathogen loads from manure on the environment and crops at field-scale. The United States Department of Agriculture, Natural Resources Conservation Service (NRCS) offers the Conservation Practices Physical Effects matrix and associated planning tools that qualitatively describe how NRCS's conservation practices affect natural resources and the socioeconomic environment. The current toolbox lists 169 conservation practices for which environmental effects are interpreted, only one of which applies directly to livestock excreta.

Thus, it is imperative to build knowledge on how production-scale animal husbandry and forage crop management practices can influence the accumulation, fate, transport, transformation, and ecosystem effects of N, C, P, antibiotics, and microbial pathogens from ruminant CAFOs. Our multi-disciplinary research team will provide a quantitative understanding of the fate, transport and transformation of N, P, C, antibiotics, and microbial pathogens in soil, water and crop plants with beef and dairy manure applications. The team consists of plant scientists, soil scientists, hydrologists, engineers, toxicologists, a microbial ecologist, and an industrial engineer who have unique expertise to successfully conduct this project. The team also has preliminary results from their research projects which are closely relevant to and support project goals such as: create effective monitoring and remediation platforms for P, N, C, antibiotics and antibiotic resistant bacteria in plants/soil/water using biochar; analyze microbial pathogens and soil microbial communities via molecular tools to ensure soil health and understand fate and transport of fecal microbes; enhance phytoremediation of high-P or -N soils; and, understand fate, transport, and transformation of contaminants to include microbial profiling and phytoremediation via modeling. Ultimately, we will develop an integrated modeling framework with an extensive field monitoring program to be conducted to advance our understanding of manure's value as fertilizer and soil health enhancer by addressing agricultural, environmental, economic, social, and health impacts. The approach integrates field experiments, laboratory studies, and field-scale modeling using the Agricultural Policy Environmental eXtender (APEX) model.

Animal well-being is a major concern for any dairy producer. Well-being focuses on many different aspects. In the past, research efforts have focused on heat stress in both lactating dairy cattle and calves. Current research efforts focus on prevention and detection of lameness as well as mastitis.

Mastitis, typically the result of a bacterial intramammary infection, continues to be a major challenge for the global and US dairy industries. In fact, it is the most common and costly disease in the dairy industry worldwide. Clinical mastitis produces visually apparent signs of disease such as abnormal milk and a swollen mammary gland whereas subclinical mastitis (SCM), which is up to 40 times more common, does not display visual signs of disease and requires a diagnostic test for identification of affected glands. As a result, most SCM remains undetected and contributes to the sustained presence of mastitis pathogens in the herd and continued reductions in milk yield and milk quality. The culmination of these effects results in sustained impairments in animal health and well-being, while also hindering profitability via losses in milk yield and greater veterinary expenses. On-farm, in-line sensors are ideal tools for real-time diagnosis of mastitis; unfortunately, current commercially available inline milk sensors that may claim to detect mastitis perform poorly in detecting precise temporal changes in milk fat, protein, and lactose concentrations. There is an obvious need to identify subclinical mastitis infections more precisely, rapidly, and efficiently, along with the causal agent, to allow for specific intervention measures to mitigate losses encumbered by the producer.

The goals of our proposed R&D are to improve mastitis control by developing and refining precision dairy monitoring technologies to accurately detect mastitis as a means to earlier intervene and lessen the economic loss arising from mastitis. The main short- and long-term objectives of this R&D are to: apply a novel, recently developed Raman Spectroscopy (RS) and/or other sensors to create a diagnostic approach to detect spectral signatures in subclinical, mastitic milk; exploit the well-known biochemical changes that occur in milk due to Gram-positive and Gram-negative infections via differences in RS spectra to differentiate Gram-negative and Gram-positive mastitis; identify the causal agent to aid in the selection of antibiotics for mastitis treatment; quantify key milk components and identify hallmarks of quality milk; further explore the utility of RS in detecting other notable diseases in lactating dairy cows that are recognized to alter milk composition; and ultimately develop an in-line Raman spectroscopy or another sensor prototype suitable for inclusion in an automated milking system.

The significance for these research endeavors is that creating a practice capable of accurately detecting SCM in real time in a non-invasive and non-destructive manner would allow for earlier and informed treatment intervention by the producer to reduce the impacts and duration of mastitis cases, and consequently, improve herd health and profitability. We also anticipate that RS can be used at dairy farms to monitor milk quality.RS detects structural changes in cow biochemistry and such changes are reflected in structural and compositional changes of milk. Our preliminary data show that the spectroscopic signatures of milk with high somatic cell count (SCC) are significantly different from milk with medium and low somatic cell counts (Figure Below). Notably, the altered spectral signatures are a consequence of both changes of mammary gland physiology (i.e., changes in milk component synthesis and secretion and the recruitment of immune cells and related soluble factors) and the presence of the infectious bacteria and their associated soluble factors in mastitic milk. The altered biochemical composition can be used for quantitative diagnosis of mastitis via a non-invasive and non-destructive Raman-based analysis of milk. Our results show that low SCC (no mastitis) can be identified with 92-95% accuracy, whereas high SCC milk is correctly classified as milk originating from a mastitic quarter with 88% accuracy. The high accuracy and specificity that resulted from this study is a direct result of utilizing RS. Raman spectroscopy is not limited in the same way mid infrared technologies are and is a more robust analytical technique, resulting in more accurate information for the producer. Ultimately, the application of this technology will help mitigate the expenses of one of the most common and expensive diseases in the dairy industry and reduce its prevalence and occurrence on farm. Our overall long-term vision is that RS and/or other integrated sensors will serve to be a valuable inline sensor capable of detecting real time changes in milk composition. First efforts will seek to expand and validate RS's ability to quantify changes in milk composition arising from mastitis. Immediate follow up efforts will be to exploit the disparities in the RS spectra that result from gram-negative, gram-positive, and other key mastitis pathogen infections. Development, installation, and utilization of an inline sensor will/should occur simultaneously with these activities. The notable limitations in infrared technologies have precluded progress from being made in the real time analysis of milk components and composition. Development, utilization, and continued refinement of RS will serve to be a valuable tool that better serves dairy producers and improves animal health and producer management decisions.

Priority Two: Sustainable Production Systems - Peanut and other Cropping Systems

The Peanut Breeding and Genetics Program in Stephenville dates back 75 years. Today we are focused on using the latest technologies to produce improved peanut cultivars and provide the translational research and IP necessary to develop and produce high-quality, safe, and sustainable food with local, national, and global impacts.. The first certified Spanish variety was released from the program in 1950. Since that time, the program has continued to meet the needs of today's modern farmers. We concentrate on cultivated peanut variety development, enhancement of disease and pest resistance, tolerance to water deficit stress, oil composition for shelf life and enhanced coronary health of consumers, wild species gene introgression, germplasm maintenance, renewable fuels and development and use of genomics tools for breeding. To date, the program has released over 22 improved variety and germplasm lines specifically suited for growers in Texas, nationally and internationally. Peanut quality has been an important emphasis of the program. For 20 years, we have released exclusively high-oleic peanut varieties, which both have a longer shelf life and have benefits for the coronary health of consumers. Our program has been a leader nationally in release of high-oleic peanut; while many other breeding programs are still releasing peanuts with conventional oil chemistry or are debating the amount of effort to put into such an endeavor, we have focused on this, and are part of an effort with shellers to make Texas a producer of exclusively high-oleic peanuts of all market classes. When fully implemented, this will guarantee high purity for this trait in all lots of peanuts produced, meeting new industry guidelines for trait purity. The Texas A&M AgriLife Peanut program in Stephenville is currently focused in several critical areas of research: development of peanut cultivars to improve grower profitability, addressing the nutritional needs of an ever-increasing world population and identifying and utilizing traditional and novel crops to uniquely serve the Cross Timbers area.

Grower profitability

Profitability is addressed through improved cultivars focused on critical issues associated with peanut production. The single greatest concern in this area is drought tolerance. Groundwater depletion, climate change and ever-increasing competition from population growth have led to increased interest in drought tolerance in peanuts. West Texas irrigates its crops from the Ogallala and the levels of the aquifer are decreasing yearly. The median water levels of the aquifer in the Texas Panhandle are estimated to have dropped from 80 to 200 ft. in the 70 years since irrigated agriculture began. Efforts to regulate and reduce the amounts of water that can be used for irrigation from this and other aquifers are rapidly progressing. This coupled with the severe drought of 2011 led our breeding efforts in a new direction and we have been dedicating much of this project and its funding to the development of drought, heat, and salt tolerance in peanut breeding lines for the past several years. The project has made significant advances in drought tolerance for Texas peanut farmers. Our efforts began by screening the peanut mini-core accessions to determine which of the accessions had drought tolerance. Seventeen traits were measured, including yield, flowering, plant height and width and others. To date, we have developed 28 SSR markers associated with the traits that we measured to identify levels of drought tolerance. We are beginning to use these markers in our efforts to develop drought tolerant peanut varieties. Several lines have performed well in the statewide irrigated advanced line trial, performing at the top of the test for multiple years of testing. In addition, our program is beginning to develop methodologies for data collection that can not be detected by the human eye using high throughput phenotyping equipment, such as Raman Spectroscopy (RS). The enormous potential to assist in the development of new drought tolerant varieties using high throughput Genomic and Phenomic technology is exciting and we feel represents the future of our program. We currently are increasing what will become our first drought tolerant cultivar. In addition, we are utilizing our one-of-a-kind wild species germplasm collection to identify additional drought tolerance traits for introgression into cultivated peanuts. Other key issues we are focused on include improved yield and grade, as well as multiple disease resistance. We are developing cutting-edge genomic and phenomic tools that will allow us to quickly identify novel traits and move them into our elite germplasm.

Partnership with Chevron Technology

Another exciting project that has the potential to be transformative in Texas Agriculture is a partnership with Chevron Technology Ventures to develop a renewable fuel market. Peanut is one of the highest-yielding annual row crops for oil content, with an average potential oil yield of over 250 gallons per acre or about six times that of soybean. Additionally, peanut is a legume like soybean and contains a similar carbon footprint for producing the crop. Legumes make excellent rotation partners and require less fertilizer applications than other feedstocks. Currently, food grade peanut variety oil content is approximately 48%. However, several sources of high-oil peanuts are known, and 'Diesel Nut' breeding lines with higher oil (>55%) content have been developed. Major advances in disease resistance have allowed for release of food grade varieties with resistance to nematodes from wild species, Sclerotinia blight and tomato spotted wilt virus (TSWV) which, once incorporated into the 'Diesel Nut,' will have the potential of creating a robust renewable diesel feedstock. Peanut oil has long-term storage properties that would be particularly desirable in fuel storage. Use of DNA marker technology has been effective in assisting with selection of desirable traits from wild species, to combine wild species genes with the higher yields in cultivated peanut and can be applied to "Diesel Nut.' This new 'Diesel Nut' has the potential to create an entirely new industry that can have a positive environmental impact around the world and help revitalize rural America. Currently oil yields approximately 25 to 50 gallons per acre for soybean. 'Diesel Nut' breeding lines were created under a previous project collaboration with Chevron that had theoretical yields of over 350 gallons per acre under ideal conditions. As the renewable diesel industry grows there will be a need to adapt the 'Diesel Nut' to new growing regions across Texas and the U.S. that present their own set of challenges for maximizing production. Limited irrigation and dryland production are two key targets that hold potential to expand the production area of the 'Diesel Nut.' This, coupled with the development of BMP's for crop production systems and the logistics of harvest, transport, and storage, will be necessary to rapidly advance production of renewable diesel feedstocks. Producing dedicated 'Diesel Nut' for renewable diesel will be a paradigm shift for farms of the future and will require major involvement of Extension (outreach) resources to demonstrate the agronomic and economic potential of high-yield dedicated energy crops to the agricultural community. We expect meaningful results and data that will enhance renewable diesel feedstock availability in a time frame of 5 years.

Improving Nutrition

Improved nutrition is a goal our program is uniquely suited to address. Peanut is a highly nutritious food protein source worldwide and has the potential to make an even greater impact on world hunger and malnutrition. Peanut paste is widely used by humanitarian organizations, including the USA World Food Program, to provide urgent food assistance to impoverished and vulnerable communities suffering war, natural disasters or drought. The World Health Organization includes peanuts and peanut butter as the "gold-standard ready-to-use therapeutic food" for treating extreme malnutrition in children and other nutritionally vulnerable people. Peanuts have higher protein content than tree nuts, in addition to many important vitamins and minerals. However, further improvement is needed to meet the increasing global demand for protein-rich foods. Peanut contains adequate daily recommendations of 7 of the 9 essential amino acids required to be considered a complete protein source. This superfood status is given when a food contains all the necessary recommended daily allowances of the amino acids that are necessary to serve as building blocks for the body's nutritional needs. By developing new germplasm with all 9 essential amino acids and other increased nutritional content we will enable the peanut industry to promote additional health properties, as well as increase overall peanut consumption. Any additional claims that can be added to the already strong foundation could only enhance peanut crop value. Peanut research has made progress in developing and distributing disease, insect, and drought resistant seed but there is a substantial need for improved nutrition. For example, plant based proteins will play a critical role in feeding our expanding population and niacin is associated with increased heart health as well as other attributes associated with overall well-being. Cultivars with all 9 essential amino acids, beneficial biomolecule content, as well as high-oleic oil ratio have been identified by stakeholders including health officials, breeders and manufactures as areas that are essential for continued industry profitability. Our long-term goals are to increase the nutritional value of peanuts using a multi-disciplinary peanut germplasm screening platform, including the use of genomics, physical characterization and chemical profiling. Peanut suffers from a narrow genetic base that leaves it isolated from many beneficial genes present rest of the Genus Arachis. Previously completed and ongoing activities by key project personnel include using exotic and cultivated germplasm in breeding efforts to expand the genetic base for several traits of interest. Preliminary research indicates target amino acids are present in our germplasm and are under genetic control. Again, the use of RS is being used for chemical fingerprinting and can be used to distinguish differences in nutrient and chemical components of plant tissues. Preliminary data already obtained by RS identified some chemical signatures associated with protein content and high-oleic oil. We have also used RS to identify different Arachis species and even cultivars because they exhibit distinct Raman spectra that can be used as a "bar code" for their identification. Our goal is to determine if these signatures can be used to identify traits that can be moved into cultivated peanut. Experiments are also underway for advanced peanut transformation and cutting-edge gene editing technologies that can speed the improvement of genetic traits.

Novel and Traditional Crops Across the Rural-Urban Nexus

Our proximity to the largest growing urban center in the state as well as our association with Tarleton State University allow us to apply a fresh look at several traditional crops in our area as well as explore unique opportunities. We have already been involved with the use of Hi-A corn (healthy corn) feeding studies at the Southwest Regional Dairy Center. We are heavily involved in organic research, breeding and their use in novel cropping systems. Recently we have also begun to explore the use of Biochar in crop production as well as the use of new cropping systems to minimize our carbon footprint through increased nutrient holding capacity and creating an overall healthier soil. Additionally, we have produced exciting results in the use of beneficial endophytes to impart drought tolerance. In other areas we are beginning to explore the use of new cover crops such as cowpeas, mung beans and soybeans for our area. We are exploring other traditional crops such as wheat for cover crops in vegetable production. Historically, Texas grew as many acres of fresh vegetables as the leading producing states, but due to lack of adequate cultivars, pest/disease pressure, and production practices, Texas growers have migrated to other crops, largely abandoning vegetable production. As a result, Texas is currently a net importer of vegetables, more than 7.5 billion pounds in 2014. The top three deficit vegetables – tomatoes, potatoes and lettuce – account for 70% of that deficit. Increasing vegetable production in Texas will significantly impact local economies, especially on farms. Related to this is our recent official organic certification of a plot land at our center which allows us to engage in active organic research in a nationally recognized program. We continue to look for opportunities to provide the translational research necessary to develop and produce high-quality, safe, and sustainable food and fiber systems with local, national, and global impacts.

Priority Three: Economic Strength - Natural Resources and Ecosystems Restoration

Enhance the efficiency, profitability, IP strategy and resiliency of agriculture, natural resources, and food systems in the state of Texas and around the world.

a) **Restoration Ecology and Pollinators** - The plight of pollinators has been widely reported, with declines of many species, including honeybees, native bees, and monarch butterflies all receiving attention in the popular and scientific press. The pollination services provided to both agriculture and the environment by insects are valued in the multiple billions of dollars. Habitat loss and fragmentation plays a large role in pollinator decline, as does the presence of established and emerging pathogens. Habitat restoration is a critical component for pollinator recovery efforts. Efforts to create pollinator habitat at the scale of backyard, reclaimed croplands, restored pipeline sites and drilling pads all contribute to providing safe havens for pollinator recovery and re-establishment. Our pollinator habitat restoration efforts connect seamlessly with our efforts to restore and re-establish diverse and stable native plant ecosystems across degraded and fragmented habitats.

b) **Wildlife and Conservation Efforts** - Wildlife has become a major land-use component in Texas and our region. This includes aesthetics-focused new landowners, recreational industry such as parks and outdoor activities as well as ranchers interested in hunting and fishing lease income. There is a myriad of winners in this scenario: human health improves with outdoor recreation such as birding and hunting; the environment stabilizes with lower ranch stocking rates and grassland/savannah restoration; and the region’s economy strengthens with diversified income.

c) **Suitability of selected native plant species for enhancing wildlife diversity** - We need to better understand how individual plant characteristics and the management of restored ecosystems affects their use by native wildlife. Because of the high degree of variability with model species, some phenotypes may be more suitable for wildlife restoration than others. Morphological variation among phenotypes may affect their suitability as nesting cover for northern bobwhite and other grassland birds; plant community characteristics such as interplant distances may alter suitability as feeding and escape cover, and plant phenology, productivity, nutritional value, and seed persistence in the environment may affect their usefulness as food for various wildlife species. Native grasslands, and their associated wildlife such as northern bobwhites, deer, predator, are one of the most imperiled plant communities in North America.

d) **Water Microbes and Streams** - There's a need to increase agricultural production while decreasing contaminants that negatively impact the environment. Historically, our local watershed has been impacted by intensive agricultural production by both microbes and nutrients. AgriLife scientists are responding to the challenges by developing more sustainable production systems to decrease or eliminate agricultural inputs of nitrogen, phosphorus, microbes, and pharmaceutical products in our local river and streams. Our goal of closed-loop dairy production involves converting dairy wastes from pollutants into biochar fertilizers that release nutrients at a much slower rate so that plants can absorb and use the valuable nitrogen and phosphorus for growth. A waste product that costs producers for disposal is being converted into a fertilizer commodity. AgriLife scientists are also developing new methods for microbial detection to rapidly identify and quantify microbial pathogens in waterways, potentially saving time and expense for regulatory agencies that monitor biological pollutants.

e) **Native Plants** - Native plants are key to maintaining and restoring many ecosystems in and around our northcentral Texas rural-urban nexus. Besides the intrinsic value of conserving diverse native germplasm, these species can stabilize function and economic viability of managed natural resources. Restoring degraded rangeland with diverse plant ecosystems that support wildlife, pollinators and birds are a prime example. Rural and urban landowners alike are interested in additional income and human health generated from restored plant ecosystems. Our goal is therefore to "domesticate" native Texas germplasm in a systematic, scientific approach for rural, urban and peri-urban settings. This will rely heavily on ongoing cooperation with Native Texas Seeds. Multiple Texas A&M AgriLife Research scientists, together with Native Texas Seeds, will collect germplasm, evaluate it in the field and eventually release promising ecotypes for commercial application in ornamental horticulture, natural ecosystem restoration, and agricultural production around the state. Our contribution will be to provide scientific techniques and methodologies that streamline the currently cumbersome process. These include genomics, micropropagation, seed science, improved establishment and post-establishment management that fosters persistence.

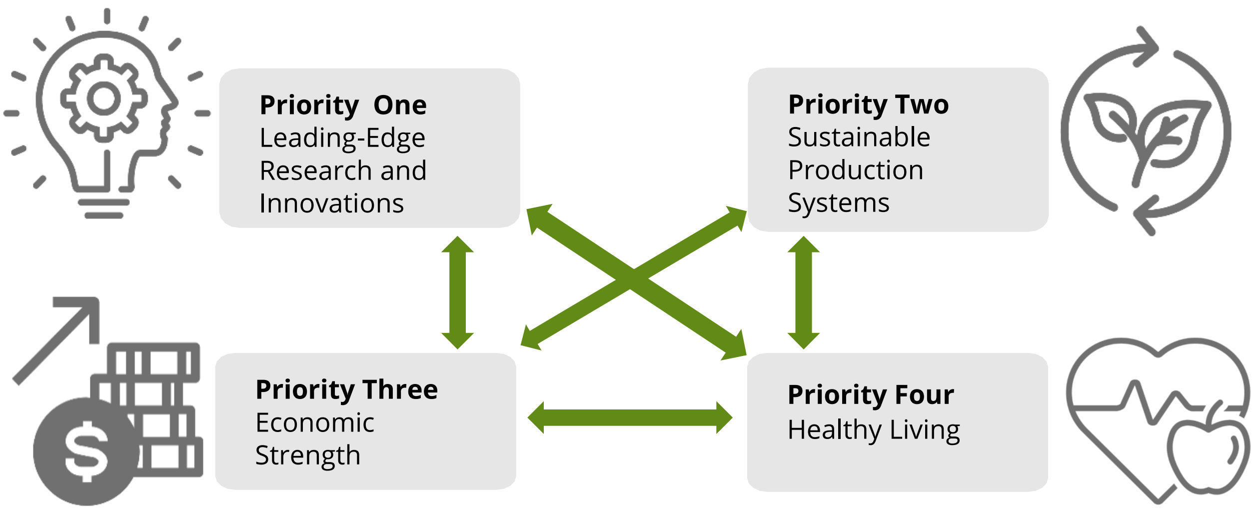
Genomics in support of native plant development - We will bring the power and efficiency of molecular techniques developed in crop sciences to native plant development. Molecular projects will more succinctly define the ecotypic nature of native plant populations, help us to rapidly select superior native populations for use and commercialization, and link specific restoration needs to genetic adaptations of certain native plant populations to more rapidly supply the necessary plant materials.

Fungal endophytes to enhance native plant performance - We need to better understand the role of fungal endophytes on native plant establishment and persistence, and to discover techniques to restore natural fungal-plant symbiotic relationships that impact native plant establishment and persistence. In addition, we will also explore the potential for development of fungal endophytes that may function as biological control agents for problematic invasive species such as old-world bluestems, which are a significant limiting factor to successful native plant restoration in much of Texas.

Novel plant propagation to accelerate native plant seed and vegetative multiplication - we will work to apply state-of-the-art techniques from crop systems to native plants, such as micropropagation and transcriptomics, to speed up production of commercial supplies of plant material and seeds to better meet market demand.

AGRILIFE RESEARCH STRATEGIC PRIORITIES

Figure 2. Synergistic interactions among our research priority areas



Priority One: Leading-Edge Research and Innovations

Discover new innovations, technologies, and science-based solutions to enhance agricultural and ecological systems and the life sciences.

Sustainable Dairy Production and Ecosystems

Erath County is at the epicenter of Texas dairy production. This industry is a major income generator for the region and provides vital nutrition to adjacent urban populations but also creates some environmental concerns. The Southwest Regional Dairy, managed by Tarleton State University and situated next door to our Center, was created to address current and future production limitations as well as environmental issues. Its state-of-the-art facilities and 300-cow production are the public front to the TAMUS dairy efforts.

Maximize Production

Our efforts will seek to maximize production through intensive research and development looking at feeding, animal wellness, and reproduction. Efforts include evaluating novel feeds and supplements that increase production, foster animal comfort and health, lower costs and reduce environmental concerns. The major research focus should be dairy and ruminant nutrition surrounding dairy, but other species can be studied as justified. Research will include taking full advantage of local forage, rangeland and agro-industrial byproducts for feeding dairy cattle. Other opportunities include small-scale peri-urban and urban animal production that contributes to food, recreation and human health. As urban and peri-urban populations increasingly encounter agriculture, quality of life as well as land size fractioning make creative but biologically, environmentally and financially viable ruminant nutrition socially, culturally and economically important.

Nutrient Management

We will integrate short and long-term laboratory and field-scale experiments to improve the knowledge in fundamental processes of soil nutrient management of dairy waste phosphorus, nitrogen, industrial and pharmaceutical chemicals. We will research the use of biochar and plant phytoremediation to mitigate and enhance soil health while minimizing environmental impacts. The primary outcome will be the ability to quantitatively assess soil and water quality impacts of manure application practices and efficacy of management practices in various soils, crops, and climate regimes. These will ultimately provide guidelines for safe and sustainable application of manure which will be highly beneficial to the dairy, agricultural and conservation programs.

Microbial Community Assessment and Optimization

Pharmaceutical residues and microorganisms in dairy manure impact soil, livestock and human health. There is potential risk of animal and human exposure to waterborne contaminants such as pathogenic bacteria and antibiotic residues originating from manure and dairy farm wastewater. We will research and develop management tactics that optimize beneficial soil microbes while lessening the impacts and persistence of harmful microbes and chemicals. One promising avenue we are pursuing, conversion of manure to biochar, simultaneously removes or negates the negative effects of harmful microbes and pharmaceuticals, including antibiotics and resistance genes. Likewise, these studies will also identify best practices for increasing and promoting beneficial microbes for soil health and water quality.

Priority One also addresses the need to access, contribute, assemble, and uses relevant data and information involving crop and animal germplasm, agroecosystem expertise, climate, and biotic and abiotic stresses to develop and assess the site-specific suitability for producers, as well as evaluate long-term health and the environmental risks related to new varieties/breeds.

The research includes, but is not limited to:

- Plant and animal improvement using the latest technologies, such as genome editing, bioengineering, synthetic biology, and breeding tools
- Gene editing systems — develop methods to create valuable mutations in model and non-model organisms and/or cell lines
- Gene drive systems — develop means to control pests, pathogens, parasites, or vectors
- Characterize natural and induced plant diversity more comprehensively and in new dimensions
- Animal and plant genetics — improve productivity, disease resistance, and nutritional value
- Plant and animal health, microbiomes, endophytes, and beneficial interactions
- Existing and emerging plant diseases and pathogens (for example, insect- vectored, fastidious) — detection, identification, control, prevention, and/or treatment
- Bioenergy/biofuels — new value-added bioproducts and processes

Expected outcome

Leading-edge research and engineering conducted in this priority will empower the discovery of new knowledge, develop new technologies, and create science-based solutions to achieve economic efficiency, resiliency, and sustainability of food production systems. Using genomics/bioinformatics, modern genome-editing, bioengineering, and breeding tools combined with the benefits of exploring genetic diversity and data science would lay the groundwork to further improve animal and plant varieties. Big data, AI, model systems, and other approaches that lend themselves to robust inferential approaches may be especially valuable in alleviating problems that have been most recalcitrant to conventional approaches (for example, understanding and improving crop root systems). Priority One research will increase knowledge of animal, soil, and plant microbiomes and benefits to the food production system. It will also lead to gaining fundamental knowledge in early, rapid detection, mitigation, and prevention of plant and animal diseases; the mitigation of biotic and abiotic stresses; and improvement of the nutritional value of foods.

Priority Two: Sustainable Production Systems

Provide the translational research necessary to develop and produce high-quality, safe, and sustainable food and fiber systems with local, national, and global impact.

Priority Two addresses agricultural productivity and environmental sustainability, key components of resilient production systems. This priority takes advantage of new discoveries and scientific advances that generate a wealth of information on agriculture system elements. For instance, CRISPR technology allowed the creation of more diverse crops and livestock, permitting the development of new food sources and traits. Innovative crop and animal production systems can lead to improved carbon sequestration strategies. These, in turn, make agriculture systems more resilient to biotic and abiotic stresses, increase yields, and enhance the quality of food, feed, and fiber.

The agriculture sector has the potential to be a net carbon sink for greenhouse gases because of its ability to sequester carbon in soil and plants and reduce methane and nitrous oxide emissions. Conservation agriculture, crop rotations, residue management, animal agriculture, and minimizing food waste are practices that can increase productivity and have economic, environmental, and social benefits. However, carbon credit markets will need effective methods to quantify and verify changes in soil carbon stocks. Successful research programs within this priority will require transdisciplinary teams that can integrate knowledge and tools from the life, health, and social sciences with engineering and computing sciences, thus creating a synergistic effect at the interface of multiple disciplines.

The research includes but is not limited to:

- Soil health — sustainability, reducing loss and degradation
- Soil-plant resiliency — increasing soil organic matter and improving microbiome interactions
- Optimizing the use of water in crop production
- Increasing nutrient use efficiency in crop production systems
- Animal epigenetics, reproduction, nutrition, and welfare

- Precision livestock production systems
- Precision crop production systems
- Carbon sequestration promotion/quantification methodology
- Agriculture production under protected environments
- Using systems approach for digital in-season crop management systems
- Digital forage/livestock production systems
- Internet of things and connectivity in agriculture
- Responsive agriculture

Expected outcome

Priority Two takes advantage of leading-edge research, technologies, and genetics to provide the translational research necessary for developing and producing high-quality, safe, and sustainable food and fiber systems with local, national, and global impact. Sensor and remote sensing technology (for example, unmanned vehicles, connectivity) will enable rapid detection and monitoring of processes across all areas of the food production chain, resulting in:

- Advanced high-throughput phenotyping systems based in machine learning
- Satellite-based automated systems for in-season large-area prescription management and yield forecast.
- Controlled environment agriculture for horticultural crop production systems
- Precision livestock farming
- Nutrition modeling
- Artificial intelligence and decision support systems

Work in this area will require transdisciplinary cooperation to integrate components of the food system into a functional and sustainable production enterprise.

Priority Three: Economic Strength

Enhance the efficiency, profitability, and resiliency of agriculture, natural resources, and food systems in the state of Texas and around the world.

Priority Three focuses on the food production systems' economic strength and profitability.
While this system has, at times, been strained by drought, freezing weather, labor and trade issues, and, more recently, by catastrophic weather events and a global health crisis, it is resilient. It continues to produce and deliver a variety of nutrient-dense foods needed to maintain our health. U.S. consumers are blessed by the abundance and relatively low cost of food, expending only 6.4% of their income on food at home.

The diversity of Texas' food supply is one of the state's greatest strengths. As the food supply chain has faced these challenges, research that provides a diverse, consumer-oriented food supply has enabled the state to offer the public other food sources, such as animal meat protein, milk, grains, and fruits and vegetables, and food delivery methods. Research under this priority will lead to new production systems resilient to environmental challenges, and the identification of new and expanding markets capable of providing healthy, safe-to-eat, locally produced food.

The research includes but is not limited to:

- Profitability of controlled-environment agriculture systems under greenhouse
- Optimizing animal and plant production systems from agriculture to consumer use
- Alternative, abundant, and high-quality water sources
- Relationship between energy availability and economic strength
- Carbon Credit strategies for producers
- Water policies/pricing/demand
- Economic and cost-benefit analysis
- International market opportunities and challenges

- Transportation and infrastructure challenges

Expected outcome

Priority Three will result in a better understanding of how changes in the production environment and agriculture policies affect the profitability and resiliency of the food supply chain. Economic and cost-benefit analyses will guide producers, consumers, and policymakers on the economic viability of new plant and animal production systems, considering socio-economic production constraints, as well as transportation and infrastructure needs. Constant feedback between this priority and priorities one, two, and four is paramount for the economic and environmental sustainability of the Texas production system. Economic and sustainability analyses will allow more efficient allocation of precious resources by identifying current and future opportunities and threats to satisfy the constantly growing food, nutrition, and human health demands and challenges for Texas and the world.

Priority Four: Healthy Living

Discover, disseminate, and facilitate the adoption of scientific evidence at the intersection of nutrition, human health, and agriculture.

Priority Four concentrates on nutrition and human health. Food contains macro- and micronutrients essential to provide energy, meet physiological needs and functions, and help prevent or mitigate the burden of many chronic diseases. The consumption needs of humans are complex. Therefore, understanding the interactions between food access, availability, choice, consumption, and composition is critical in the context of individual nutrition needs and growing global food system demands. This understanding is also essential for supporting food environments and product development that meet consumer preferences and nutritional needs to optimize human health throughout the lifespan.

Optimizing food systems for economic, environmental, and human health includes consideration of food waste and food safety. Food waste is responsible for billions of dollars lost in food productivity and availability for consumers. In addition, food safety issues add to these losses. According to the Centers for Disease Control and Prevention, food-borne diseases cause approximately 50 million illnesses and contribute to more than 125,000 hospitalizations and about 3,000 deaths in the U.S. each year.

The research includes but is not limited to:

- Discovering evidence relating nutrients in food and human disease prevention
- Precision nutrition and health across the lifespan
- Consumer preferences and acceptances in diverse populations
- Community-engaged intervention, development, and testing
- Dissemination, including implementation of science and policy-related initiatives
- Technology innovations to capture real-time consumer responses to interventions
- Targeted message delivery to test or support behavioral adoption/adherence
- Facilitating the translation of effective interventions with relevant systems and partners (AgriLife Extension, health care, public health, community-based organizations)
- Nutritional optimization of foods in the marketplace
- Food waste/losses/mitigation
- Food safety/security
- Food design engineering — packaging, conservation

Expected outcome

Focused on nutrition and human health, Priority Four integrates fundamental knowledge and new discoveries from the other priority areas to create an interdisciplinary pathway toward cutting-edge innovations, translational research, and a broad spectrum of dissemination strategies that advance human health through agriculture and food system optimization. Work in this area is expected to:

- Illuminate consumer preferences, acceptance, and demand in diverse communities
- Rigorously evaluate the effects of prescriptive diets and/or nutritional products on a variety of health-related outcomes

- Develop technology and tools that enable consumer adoption of personalized dietary and related health recommendations
- Identify mechanisms by which pathogens in food and animals contribute to food safety issues and develop food safety mitigation strategies
- Facilitate the adoption of relevant programs and approaches to improve public health through nutrition

AGRILIFE RESEARCH COMPETITIVE ADVANTAGES

AgriLife Research is the leading research and technology development agency in Texas for agriculture, natural resources, and the life sciences. Since 2017, it has been ranked #1 by the National Science Foundation among its peers regarding federal funding in agricultural sciences and natural resources conservation. AgriLife Research is supported by 15 academic departments of the Texas A&M University College of Agriculture and Life Sciences, five departments within the School of Veterinary Medicine and Biomedical Sciences, 13 Research and Extension centers across Texas, and eight multidisciplinary institutes. More than 600 academic faculty contribute to AgriLife Research initiatives.

In addition, AgriLife Research manages several state-of-the-art core research facilities, such as:

- The AgriLife Genomics and Bioinformatics Service, which provides support to researchers on nucleic acid sequencing and genotyping
- The Texas A&M Institute for Genomic Medicine, where animal models are used to address chronic diseases
- The National Center for Electron Beam Research facility, which engages with
- the food industry and with NASA to examine the use of non-ionizing irradiation to enhance the safety and shelf stability of foods
- The Multi-Crop Transformation Facility, where modern plant genetics are studied in cell culture and then those cells are stimulated to develop whole rooted plants for field testing
- The Plant Growth and Phenotyping Facility, which develops big data solutions for the precision growth dynamics of crop plants

The research carried out by AgriLife scientists applies to a variety of systems, providing solutions to agriculture- and life-science-related challenges at the state, national, and international levels.

Texas is geographically and climatically diverse. The state provides a platform for AgriLife Research scientists to develop solutions relevant to a vast array of global agricultural issues. Variations in precipitation and humidity, elevation, salinity, soil textures, solar radiation, and average daily temperatures across Texas make statewide research relevant to most of the world's ecosystems and overall global issues. Diverse funding sources enable AgriLife Research to study agriculture-related matters of importance to Texas, the nation, and many other countries.

A sample of the many possible researchable areas include:

- Improving the efficiency of food production while conserving soil, water, and natural resources
- Genetic improvements of plants and animals
- Bioenergy
- Animal and human nutrition
- Production economics
- Trade
- Effects of climate change on all the above
- Policies to help mitigate the effects of climate change

Through enduring investments in research, AgriLife Research has accumulated growing volumes of data from genomics, phenomics, phenotyping, livestock, field crops, and rangeland management. This availability of data presents a marked, if not unique, occasion to identify research focal points that will address agricultural threats and opportunities. Appropriate big data analyses that integrate the perspectives of agriculture, biology, physics, mathematics, computer science, and engineering can provide the necessary insight and understanding to illuminate key current and future opportunities and challenges in food production.

OUR COMMITMENT: STRENGTHENING OUR CAPACITY TO SERVE

Continuing to advance agriculture in our three priority areas requires a corresponding commitment to grow and strengthen the scientific enterprise of AgriLife Research, and specifically STEP, by improving by enhancing research capacity, productivity, and impact.

Goals and promises from the Director of AgriLife Research:

- Invest in faculty and staff recruitment and retention.
- Invest in faculty support programs and other initiatives to enhance the ability of faculty to secure extramural funding and advance scholarship.
- Improve research infrastructure and facilitate access to state-of-the-art equipment, facilities, instrumentation, and services.
- Recognize and reward faculty and staff successes by nominating them for internal and external awards.
- Support training of next-generation scientists, including graduate students and postdoctoral researchers.
- Foster communication with internal stakeholders and nurture relationships with external stakeholder groups.
- Develop mechanisms for securing funding from private entities and other stakeholder groups to advance the AgriLife Research mission.

EXPANDING OUR COMMITMENT: NEW VENTURES EXPANDING OUR REACH ACROSS THE RURAL-URBAN NEXUS

Slaughter-Harris Research Proposal

The following provides an overview of the research projects that Texas A&M AgriLife Research envisions for the Slaughter-Harris Ranch in Palo Pinto County, Texas. Projects are subject to change based on funding, need, and availability of research faculty and scientists.

Sheep and Goat Research mixed with Livestock Guardian Dogs

The US cannot meet the demand for sheep and goat products, primarily lamb and goat meat. We import more than two times the amount of lamb produced in the US and roughly 40% of all goat meat consumed. Texas alone had a population of sheep and goats to meet this demand; however, federal regulations prohibit the use of toxicants that were used to manage predators. As a side note, these same toxicants are still used to manage predators in other countries that export lamb and goat to the US. To remain competitive, sheep and goat producers need to use cost effective nonlethal predator control strategies. Texas A&M AgriLife in San Angelo has developed a Livestock Guardian Dog (LGD) program that provides research and education on how LGDs can sustain sheep and goat production in the face of predators. Particularly, when raising small ruminants on medium- to large-pastures that are rough, brushy, and harbor predators. This program has shown how to improve lamb and kid crops 4-fold with properly managed LGDs that are friendly to people yet commit their lives to protecting their livestock.

After predator losses are mitigated, the next greatest challenge to raising small ruminants is breeding animals that fit the environment. This not only allows them to be healthy and productive, but it also reduces the need for supplemental feed and pharmaceutical products to sustain healthy animals. Again, our partners in San Angelo have an active research program utilizing quantitative and molecular genetics on sheep and goats. This technology allows farmers and ranchers to select animals that are fit to their environmental conditions, optimize their reproductive potential to produce 50% larger lamb and kid crops, and reduce the need for anthelmintics (dewormers) to control internal parasites. Internal parasitism is the largest health issue for small ruminants, particularly in rainfall areas that exceed 20 inches of annual participation. No new pharmaceutical products have been released in the US for three decades, as such, most parasites have developed some level of resistance to current products limiting their effectiveness and long-term use to combat an issue that can result in high rates of animal morbidity and mortality. Two new anthelmintics (Zolvix and Startec) are available to import competitors but FDA has not approved their use in the US. This is an area of research that could help small ruminant producers. Additionally, genetic breeding technology being developed and refined at the San Angelo center has shown that parasitism can be reduced by roughly 50% with proper breeding strategies. This work can be bolstered with sheep flocks and goat herds in higher rainfall environments such as the Slaughter-Harris Ranch.

Following our visit in late October, we suggest 50 sheep, 50 goats, and 4 LGDs as a very conservative starting point. This is large enough to conduct genetic research and LGD research efforts. We want to be conservative on the stocking rates of native rangelands and will increase this number if the pastures are more productive. However, overuse will reduce range conditions and negatively impact wildlife populations.

Peanut and Cropping Systems Research

We need a highly controlled environment to be used as a new nursery for the evaluation and increase of our valuable germplasm. Early generation materials must be looked at on a single plant basis several times during the season. It requires a location that is irrigated and protected from wildlife. We currently rent a field that is over five hours away, which limits the necessary evaluations we can make during the season. The river tracts of the Slaughter-Harris Ranch have good soil for peanut production as well as access to irrigation water. In addition to early generation materials, as varieties are multiplied prior to their public release, similar requirements are needed (protected irrigated fields) for the location of the increase blocks. We currently rely on peanut farmers to loan us land to accomplish this task in the breeding program. A dedicated location for both early and late generation activities that is close to our research center in Stephenville would be a huge asset to our breeding program. These areas could be small to start with but could be enlarged if needed.

Finally, there is potential to conduct replicated dryland cropping system research, such as cover crops and crop rotation, in the fields behind the main ranch house. Additionally, there is potential for breeding programs of several crops to conduct breeding trials in these same fields. The soils are well suited for wheat, cotton, grain sorghum and hay-grazer production. No-till or strip-till practices could be researched in these fields as part of the climate smart production practices that are currently being examined.

Genomics: Plant and Microbial Interactions

A location close to Stephenville would benefit efforts to identify and test beneficial plant/microbial interactions. This effort could be supported by equipment and infrastructure already requested.

For peanuts, our primary goal is increasing drought tolerance in dryland varieties. Plant interactions with endophytic microbes increase the survival rate in times of drought, allowing plants to hold on until the arrival of precipitation. Some microbial interactions may not increase yield in times of plentiful rain, but in dry years they can make the difference between a "bust" year and a profitable year. As we increasingly move to lower input, more sustainable management practices, decreasing water use while maintaining profitability is critical to producers.

Native plant restoration can also benefit from plant/microbial studies at the ranch. We are currently targeting the exotic/invasive grass KR bluestem for biocontrol, using microbes to inhibit KR bluestem seed germination in native grassland restoration efforts. KR bluestem has been identified as a major hurdle in restoring diverse, native grasslands. It is invading native grasslands, displacing existing plants/animals/ecosystems across the southern U.S., forming grass monocultures that support few native insect, bird, and animal species. KR bluestem produces copious amounts of seeds, creating a seedbed that renders herbicide control non-effective. We are using microbes that inhibit germination and establishment of KR bluestem that have simultaneous promotive effects on native grass seed germination and establishment. As we incorporate microbial biocontrol into grassland restoration, we are looking for economical, scalable, and game-changing impacts on the competition between native grasses and KR bluestem. Additional plots at the ranch would be secure and within easy driving distance for graduate students and technicians working on this potential solution to the invasive grass that is taking over Texas.

Costs and equipment for microplots to study plant/microbial interactions would largely be supplied by grant funding. Graduate and undergraduate students from Tarleton State University would conduct most of the research. The peanut endophyte work would partner with the efforts of Dr. John Cason's peanut program, while the native plant work would be conducted in connection with Dr. Jim Muir's research program restoring native plants/grasslands.

Grassland Ecology: Cultivated, Rangeland and Native Grasslands.

Develop year-round grazing systems that supplement winter or drought hay feeding

Current rangeland and pasture grazing and browsing systems for wildlife, beef cattle, meat goats and meat sheep depend heavily on purchased feed such as hay and protein supplements. When these become prohibitively expensive during crises such as drought or high fuel costs, land managers resort to selling reproductive stock during low-market prices. Our proposal is to design and test year-round grazing systems that encompass both cool- and warm-season pastures and protein banks that meet 100% of animal protein and energy needs. These will include approaches such as overseeding and interseeding legumes into predominantly grass pastures and rangeland, reserving standing hay from one season to the next, silvopasture systems using deep-rooted leguminous trees, etc.

Restoration of native plant communities to rural rangelands, forests, and pastures

As non-urban land uses and value have shifted from traditional livestock, timber, and crop production to uses centered on wildlife habitat for recreation and conservation, the demand for native vegetation to support wildlife has increased throughout Texas. The underlying trend in land use change is likely to continue as land values based on aesthetics, recreation, and conservation now vastly exceed agricultural production capability over most of the state. Conversion of non-native pastures, former croplands, or intensively managed forests back to native grassland is a high-priority land management need.

Reclamation in the energy, transportation, utility, and water development sectors

Texas has become the nation’s leader of both oil and gas and renewable energy development; this energy boom, however, has significantly disturbed native soils, watersheds, plants, and wildlife. Many landowners demand remediation using native plants to mitigate energy production impacts on private lands. Needs associated with oil and gas pipelines are particularly high at present as many as 20 pipelines are projected to be built across the state in coming years. Collectively, these easements will impact hundreds of thousands of acres such that reclamation will be needed. Similarly, as Texas’ population grows two-fold in the century ahead, significant native habitat impacts associated transportation, utility, and water infrastructure development are inevitable and will increase the demand for reclamation of native plant communities.

Compare existing native plant locations side by side with croplands and pasture

Develop carbon intensity profiles, including production inputs such as water, pesticide, and fertilizer, and how much net carbon that process adds to the atmosphere. Lower carbon intensity is important in developing sustainable, productive, and economical agricultural practices.

Research Tracks & Approach

Genomics in support of native plant development

We will bring the power and efficiency of molecular techniques developed in crop sciences to native plant development. Molecular projects will more succinctly define the ecotypic nature of native plant populations, help us to rapidly select superior native populations for use and commercialization, and link specific restoration needs to genetic adaptations of certain native plant populations to supply the necessary plant materials more rapidly.

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Wildlife and Native Plant Conservation Efforts

Wildlife has become a major land-use component in Texas and our region. This includes aesthetics-focused new landowners, recreational industry such as parks and outdoor activities, as well as ranchers interested in hunting and fishing lease income. There is a myriad of winners in this scenario: human health improves with outdoor recreation such as birding and hunting; the environment stabilizes with lower ranch stocking rates and grassland/savannah restoration; and the region's economy strengthens with diversified income.

Suitability of selected native plant species for enhancing wildlife diversity

We need to better understand how individual plant characteristics and the management of restored ecosystems affects their use by native wildlife. Because of the high degree of variability with model species, some phenotypes may be more suitable for wildlife restoration than others. Morphological variation among phenotypes may affect their suitability as nesting cover for northern bobwhite and other grassland birds; plant community characteristics such as interplant distances may alter suitability as feeding and escape cover, and plant phenology, productivity, nutritional value, and seed persistence in the environment may affect their usefulness as food for various wildlife species. Native grasslands, and their associated wildlife, are one of the most imperiled plant communities in North America.

APPENDIX: TEXAS AGRICULTURE, NATURAL RESOURCES, THE FUTURE

Agriculture

By 2050, the U.S. and world population are expected to increase by 30%, and global real incomes per capita are expected to double. Population and income growth translate into higher demand for both staple products and high-valued foods, such as more animal and plant proteins, fruits, and vegetables. Higher real incomes also mean a growing demand for livestock and feed for livestock. As a result, agricultural productivity has increased dramatically over the years. Today's farmers produce 262% more food with 2% fewer inputs than in 1950. A major component of this increase in agricultural productivity is due to investments in public agricultural research with a benefit-cost ratio of 32, which means that every dollar spent on public agricultural research and extension returns 32 dollars to society. Therefore, large benefits exist for investments in U.S. public agricultural research.

Rapid agricultural productivity increases, relative to gains in other food sectors of the U.S. economy, have translated into falling real prices of food consumed at home. For example, in 1948-2018, the share of U.S. household income spent on food at home declined from 22.3% to 6.4%, while total food consumption increased. With Americans spending 6.4% of their income on food, the other 93.6% is available for spending on a wide range of other goods and services, including recreation, housing, transportation, education, and health care. Therefore, the long-term rise of civilization and living standards worldwide largely tells a story about increasing agricultural productivity. The U.S. is the largest exporter of agricultural products. Since 95% of the world's population lives outside the U.S., the possibilities and opportunities to continue feeding the world are endless.

Agriculture has long been a mainstay of the Texas economy, and the success of Texas agriculture has paved the way for the development of new industries and sustained the diversification of our economy.

The food and fiber systems' contribution to the Texas gross domestic product (GDP) was valued at $145.8 billion in 2017. This represented 9.1% of the state's total economic activity. The top ten commodities in market value are cattle, cotton, milk, broilers, greenhouse, sorghum, wheat, fruits, vegetables, and eggs (Figure 3).

Additionally, agriculture-related activities such as hunting, fishing, and recreation, among others, are worth over $2 billion.

Cattle	$12.3 billion
Broilers	$2.9 billion
Cotton	$2.6 billion
Milk	$2.1 billion
Corn	$1.1 billion
Greenhouse	$840 million
Fruits and Vegetables	$629 million
Eggs	$500 million
Sorghum	$490 million
Wheat	$276 million

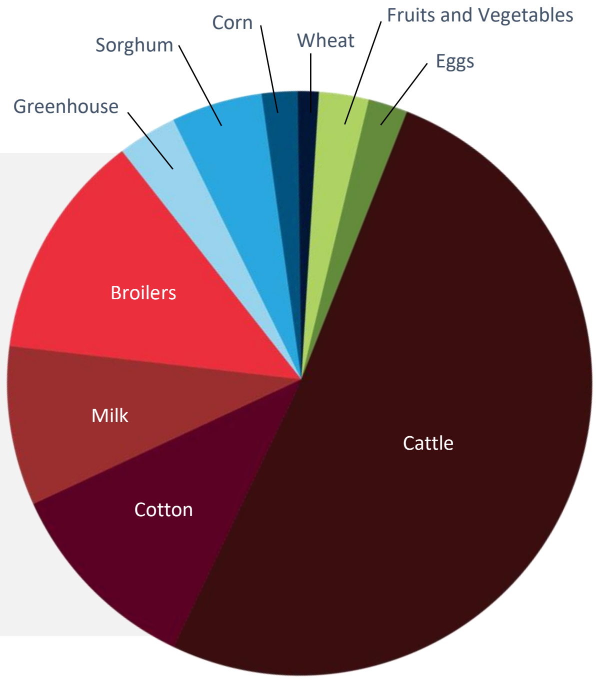

Figure 3. Texas top 10 commodities in terms of market value

Texas is the top state in the nation for producing crude oil, natural gas, and wind-based energy, which provide significant competitive advantages. In 2020, Texas accounted for 43% of the nation's crude oil production and 26% of its marketed natural gas production. Texas also has abundant renewable energy resources. It is first in the nation in wind-generated electricity and a leader in biomass-based renewable energy. With many sunny days across vast distances, Texas is also a leader in solar energy potential. Ranking second in the nation in both population and economy, Texas consumes a large share of the nation's energy. Therefore, as U.S. and world economies grow, two main variables sustain such growth — energy and food — and Texas is a key player in both. Integrating and taking advantage of the synergies of both industries will contribute greatly to the continued growth of the Texas and U.S. economies.

Natural Resources

Texas's natural resources are expansive, with nearly 172 million acres of landmass. The state is home to more than 142 mammal species as well as 615 bird species, of which half are migratory.

Freshwater lakes, ponds, and reservoirs cover about 1.2 million Texas acres. This includes nearly 185,000 miles of river, more than 350 miles of coast along the Gulf of Mexico, and 1,254 miles along the Rio Grande bordering Mexico. Texas waters house more than 250 freshwater fish species and 1,500 saltwater species.

Within this natural ecosystem, 141 million acres — more than 80% of the state's total acreage — consist of privately owned working lands and more than 60,000 working landowners. Texas working lands are privately owned farms, ranches, and forests producing agricultural products. This includes 25.8 million acres of cropland, 105.8 million acres of grazingland, 8 million acres of timber, 5.3 million acres of wildlife management, and more than 780,000 acres of other working lands.

At the same time, from 1997 to 2017, Texas lost approximately 2.2 million acres of working lands converted for nonagricultural uses. Of those acres, 1.2 million were converted in the last five years.

The Future

Texas is becoming an urban state and is home to four of the top 10 most populous cities in the country (Houston, San Antonio, Dallas, and Austin) and 69 of the top 780 cities. The Census Bureau estimates that Texas has three of the ten fastest-growing counties in the country (Hays, Comal and Kendall) and almost a quarter of the top 100 fastest-growing counties. Although Texas has a large rural population, almost 4.5 million, it only accounts for about 15% of the total, which means that around 25 million people live in urban areas.

The COVID-19 global pandemic pushed the world several years prematurely into cyberspace and wreaked havoc on the global food supply chain, causing tremendous decreases in food security. Texas was no exception. COVID-19 exposed Texans' poor health status regarding obesity, hypertension, diabetes, heart diseases, and other chronic diseases related to diet and nutrition. COVID-19 also revealed the need to examine food production and distribution systems, uncovering the need for a more agile food supply system that provides nutritious, affordable, and accessible food to consumers while financially supporting our farmers, ranchers, and agricultural workers, even when there are multifactored disruptions at one time throughout the supply chain.

We are keenly aware that hunger, specifically undernutrition, is one of our most important global issues. Both a cause and a symptom of poverty, it can ultimately lead to conflict, mass migrations, and the rise of terrorism, all of which can impact Texans. We believe that we can help alleviate human suffering associated with hunger and poverty through agricultural science and, in that way, help prevent these outcomes while building a better world for present and future generations. With proper investment today, AgriLife Research will set the foundations of the infrastructure necessary to ensure food security for future generations.

Over-nourishment presents a double-burden paradox that affects nutrition and increases the risk of chronic diseases. Texas agriculture and AgriLife Research are uniquely positioned to partner to improve public nutrition and health by providing a healthier, more nutritious, and abundant food supply.

As Texas agriculture grows, it has a positive multiplier effect throughout the economy. For every dollar of agricultural production in Texas, another $2.19 is generated by other industries in the state to support this additional output. The interconnected nature of Texas agriculture to other sectors of the economy — and the everchanging relationships across these sectors — make it imperative that AgriLife Research is positioned to anticipate and respond to critical needs and emerging challenges.

AgriLife Research's roots are firmly embedded in production agriculture and natural resources. We seek to expand the agency's focus to apply the power of fundamental life sciences to solve real-world issues. Discoveries in genetics, crop and animal management systems, and links between poor human nutrition and chronic diseases are accelerating our impacts on sustainable food and fiber supply chains. Our approach integrates basic and applied research to create, as stated in our vision, "healthy lives and livelihoods improved through abundant, affordable, and high-quality food and agricultural products in Texas and the world."