TEXAS A&M AGRIlIFE RESEARCH

PANHANDLE-PLAINS REGION

RESEARCH GOALS AND IMPACTS

Texas A&M AgriLife Research and Extension Center at Amarillo
Texas A&M AgriLife Research and Extension Center at Lubbock
Texas A&M AgriLife Research and Extension Center at Vernon
College of Agriculture and Life Sciences, Texas A&M University
Institute for Infectious Animal Diseases

2015
GOAL

Protect water quality and increase the amount of water available for urban and rural use through new technologies and approaches.

PROGRESS

Boosting irrigation efficiency

- The Texas High Plains is the state’s most intensively irrigated region, with 1.38 million irrigated acres accounting for nearly 90% of all water use. Irrigation management has been practiced here since development of irrigated agriculture in the 1950s. Advances in irrigation have been developed and implemented by farmers over time, along with crop genetic improvements. Irrigation engineers and plant scientists have shown that genetics alone, without adequate advanced irrigation system management, are not enough to meet the complex challenges facing today’s farmers. AgriLife Research irrigation engineers have teamed with crop genetics faculty to help farmers achieve advanced productivity and higher water-use efficiency than ever before, with significantly less groundwater resources being pumped from the Ogallala Aquifer.
  - Major irrigation strategies were irrigation scheduling, changing crop type and variety or converting to dryland crops, updating irrigation equipment, conservation tillage, and advances in plant breeding.
  - Successes from this research are being proposed for inclusion in developing regional and state water plans, and the tools developed as part of the research have saved producers hundred of millions of dollars by sustaining crop yields with less irrigation water per acre over the past two decades.

- AgriLife Research economists investigated economic and groundwater use implications of climate change in three heavily irrigated counties (Dallam, Hartley, and Sherman) in the Texas Panhandle’s Ogallala Aquifer region, using a new spatially explicit, dynamic, integrated model.
  - They determined that the average saturated thickness in these counties will decrease by 39.7%, 35.7%, and 42.5%, respectively, by 2050. They predict that total irrigated acres will decline due to aquifer depletion by 43.8%, 13.2%, and 12.7% and dryland acreage will increase by 109%, 116%, and 116%, respectively, by 2050.
  - Simulation models showed that adopting a water-conserving crop mix is an effective strategy for farmers in adapting to climate change by increasing 4.3%, 5.8%, and 2.1% of the net returns for producers in these counties, respectively.

- A field study at the Lubbock Center evaluated water policy based on the economics of bioenergy or food crops grown with limited irrigation in rotation with cotton. The study showed increased overall crop profitability between $74 and $93 per acre using sorghum and target irrigation rates of 60% and 80% evapotranspiration with crop rotation. When applying these scenarios to 25% of the irrigated cotton acres (about 500,000 acres) in the High Plains, the overall economic impact would be approximately $41.8 million.
• Vernon Center researchers have shown that delaying irrigation until critical cotton growth stages, as compared to banking water through pre-season or early season irrigation, can reduce water applications by 41% while reducing lint yields by only 5%. Estimating 148,000 irrigated acres of Rolling Plains cotton, water savings for the region could total 21,323 million gallons and save over $1.3 million in pumping costs.

• Amarillo researchers created a “service portal” that serves as a public gateway to information available from the Texas High Plains Evapotranspiration (TXHPET) Network, providing Internet access to weather data affecting agriculture, accurate crop water-use estimates, online irrigation scheduling tools, and other educational resources. The crop water-use data are regionally focused in the Texas High Plains (Panhandle and South Plains), where most irrigation water in the state is used, as well as in portions of the Rolling Plains and West Texas. The amount of water savings associated with this Texas Water Development Board–funded project was conservatively projected to be 201,846 acre-feet annually. The four most heavily impacted counties were Dallam, Moore, Hartley, and Sherman, since they are the largest water users. This estimated conservation impact equals only a 4.5% reduction of the regional water use per year by both regions but is significant because of the large crop acreages and irrigation water volumes pumped annually.

  o Based on a TWDB study cost of $152,400 to date for the two years, the project cost per acre-foot saved with this ET-based management project was only $0.38 per acre-foot or $0.03 per acre-inch, extremely inexpensive in terms of a benefit-to-cost ratio. The low costs justify statewide development and support of the network for future irrigation management and water conservation.

• A research team at the Amarillo and Lubbock Centers developed new software to accurately and easily compute evapotranspiration, or ET, the loss of water from the soil by evaporation and by transpiration from plants.

• The team also developed web-based irrigation scheduling tools and educational resources to improve the efficiency and efficacy of water management in irrigated crop production. A newly created Bushland Evapotranspiration (BETS) calculator software program has been completed. It serves as a tool for standardized computation of reference ET and is widely used in industry and by researchers around the world. The software program is available for mobile phones as well as personal computers.

  o This information allows growers to determine the correct amount of irrigation needed for their crops. This method has saved over 50,000 acre-feet (16.2 billion gallons) of groundwater annually for the northern Texas High Plains.

  o Results from a recent Borlaug Institute irrigation systems assessment project indicate that irrigation improvements using tools and ET-based scheduling methods developed at Amarillo, Bushland, and Lubbock could make a marked increase in production operations.
• An Amarillo and Lubbock research team has improved the ability to detect plant diseases early in the growing season by using remote-sensing technologies, allowing farmers to eliminate irrigations of diseased wheat.
  
  o By preventing a single unnecessary 2-inch irrigation on a ½-mile center pivot, a farmer could save approximately $12,000 and 28.6 million gallons of groundwater.

• Preliminary studies at the Lubbock Center on irrigation timing in cotton show potential water savings of 10% with no significant reduction in lint yield compared to traditional irrigation practices.
  
  o Subsurface drip irrigation saves more water than other irrigation methods.
  
  o Lubbock researchers also identified new cotton varieties best suited to dryland growing or to varying levels of irrigation when affected by disease or nematode pressure.

• A recent USDA Agricultural Research Service study supported a four-year Lubbock Center study showing that on a clay loam soil, subsurface drip irrigation cotton yield and quality irrigated at seven-day intervals instead of daily intervals had no negative effect and significantly increased yield by 250 pounds per acre in dry years, using the same quantity of irrigation.

• In an ongoing study at Lubbock in which rain is leveraged with very limited irrigation to optimize rain value, increases in water-use efficiency occurred with each incremental increase in seasonal irrigation. This indicates that concentrating available irrigation, even with significant rain, may be the better irrigation water-use option than irrigating larger areas with less water.

Studying the economics of climate change in the Ogallala Aquifer region

• Vernon Center researchers studying climate change in the Ogallala Aquifer region found the following:
  
  o Three Regional Climate Models predicted an overall decrease in the average rainfall, an increase in the intensity of extreme rainfall events, and an increase in both minimum and maximum temperatures in most counties in the Texas High Plains and the Rolling Plains in the future (2041–2070) when compared to historic periods (1971–2000).
  
  o Optimal crop pattern selection and mix are related to initial water availability and land distribution.
  
  o Irrigated lands in areas facing water scarcity show sharper drops in crop production, while production increases annually in areas with relatively high water levels.
  
  o Deficit irrigation is an effective strategy for agriculture and water sustainability.
  
  o With continuing water depletion, more irrigated land will be replaced by dry land and pastureland, which demand much less irrigation water.
GOAL

Sustain and support efficient use of land resources and ensure air quality in the production of food and non-food crops.

Improving groundwater quality

- High levels of nitrate in groundwater and bacteria in streams are contributing to more Texas waters being listed as impaired. Researchers at the Vernon Center found that the groundwater in the southern Ogallala Aquifer region, where shallow wells are abundant, has substantially higher nitrate, sulfate, and chloride contamination accompanied by high salinization, when compared to the northern Ogallala region. In shallow wells, about 80% and 32% of observations exceeded the EPA’s Secondary Maximum Contaminant Level for total dissolved solids (an indicator of salinity) and the Maximum Contaminant Level for nitrates, respectively, from 2000 to 2010, when compared to 22% and 3% of such observations in deep wells.
  - Agricultural producers could reduce their nitrogen fertilizer applications by 43%–72% when accounting for well water nitrates and crediting them toward crop nitrogen requirements. Vernon Center studies showed that crop yields were maintained with reduced nitrogen inputs, confirming that well-water nitrate is used by irrigated crops.
  - The Spatially Explicit Load Enrichment Calculation Tool (SELECT) was developed and adopted by state agencies to assess E. coli contamination in more than 20 impaired Texas watersheds.

PROGRESS

Conducting air quality research

- In addition to impacts on air quality for humans, more than a million cattle die from respiratory illness in the United States each year, causing economic losses in the hundreds of millions of dollars.
- Through the Air Quality: Reducing Feedlot Emissions initiative, the Amarillo Center has developed a sound scientific basis for cost-effective air quality emissions abatement measures for open-lot cattle feedlots and dairies in the Southern Great Plains of Texas and Kansas.
  - Researchers measure particulate matter, ammonia, hydrogen sulfide, odor, volatile organic compounds, and greenhouse gases to help with emissions control.
  - Scientists showed that ground-level particulate matter concentration (dust) was reduced by 54%–84% by increasing animal density in large cattle feedyards.
  - Amarillo researchers have successfully demonstrated the use of automated digital imaging followed by image processing and interpretation to visually estimate ground-level feedlot dust concentrations. Based on the outcomes of an earlier 10-year USDA National Institute of Food and Agriculture grant, they are now validating their methods in the field with a prosumer-grade Digital Single-Lens Reflex (dSLR) camera.
The researchers have also successfully demonstrated the design, assembly, and use of a low-cost, wireless network of small optical sensors to generate vertical and horizontal distributions of particulate matter mass concentrations within a feedlot dust plume.

Two national networks, the National Atmospheric Deposition Program (NADP) and the Clean Air Status and Trends NETwork, provide researchers and policymakers with standardized, high-quality, ongoing measurements of airborne nutrients that are deposited onto soils and vegetation by direct contact or by being dissolved or suspended in precipitation. NADP sites in Texas managed by Amarillo Center personnel are included in the NADP annual report of wet-deposition data. Successful participation in an NADP site has provided a valuable reference baseline database and context for discussing feedyard and dairy ammonia concentrations and emissions from other research projects.

Research on mitigating ammonia emissions from animal manure has shown that a technology involving an acid-filled gas-permeable membrane system can effectively remove and capture 50% of the ammonia from liquid dairy manure in less than three weeks.

Amarillo researchers estimated that a Panhandle feedlot with a capacity over 32,000 head could save about $40,000 per year by adopting dust-abatement practices alone.

Nitrous oxide (N₂O) and methane (CH₄), greenhouse gases that are emitted from cattle feedlots, have global-warming potentials (GWP) of 21 and 310 times that of carbon dioxide, respectively, with N₂O being the greater contributor to global warming. Little research has been conducted into the emissions of these greenhouse gases from beef cattle feedyards, particularly as it applies to climatic conditions, ration formulations used, and management practices of feedlots in the Texas High Plains, even though reporting is required by the U.S. Environmental Protection Agency. An Amarillo researcher measured greenhouse gas emissions in the spring and summer of 2014 in feedyard pens and found that both N₂O and CH₄ emissions were temperature-dependent and decreased as manure-pack temperatures decreased. Treatments were applied where the dry surface layers were removed and added to adjacent bases, to test temperature differences. With USDA Agricultural Research Service collaborators, this data is being used to develop and improve emissions models.

Collaborating with colleagues in the College of Agriculture and Life Sciences’ Department of Biological and Agricultural Engineering, the researchers installed a second open-path Fourier transform infrared (OP-FTIR) system at a commercial feedyard, providing greenhouse gas measurements for the dominant wind directions on the Texas High Plains.

Biological and Agricultural Engineering teaches a continuing professional development course on global warming and the regulation of greenhouse gases under the federal Clean Air Act.
**GOAL**

Conduct basic and translational research to minimize the unfavorable effects of agricultural production and urban communities on the environment.

Lubbock Center researchers found ways to increase overall crop profitability between $74 and $93 per acre using sorghum for crop rotation, with target irrigation rates of 60% and 80% evapotranspiration. If these scenarios apply to 25% of the irrigated cotton acres (about 500,000 acres) in the High Plains, the overall economic impact would be approximately $41.8 million.

Researchers at the Lubbock Center have found ways to improve cotton production on land infested with root-knot nematode and black root rot by using a combination of disease-resistant cultivars and chemical or seed treatments, resulting in greater yields and reduced variability in cotton growth.

- They also conduct ongoing economic evaluation of precision farming technologies.

**PROGRESS**

**Conserving soil and water in crop production**

- Environmental soil science research at Vernon has indicated that tillage has no significant effect on sorghum and cotton lint yields. Fitted models indicate that optimum lint yields and net returns can be achieved at irrigation rates of 83% evapotranspiration. Net returns across all irrigation treatments were significantly higher for no-till cotton systems ($44.54 per acre) compared with bedded conventional till systems. Thus, adoption of conservation tillage systems should not negatively affect lint yield or net returns in deficit-irrigated cotton systems in the Texas Rolling Plains, particularly during the transition from intensively tilled systems to conservation-tilled systems.

- Likewise, three years of tillage and water effects on grain sorghum production indicate that tillage does not impact grain yields. In addition, irrigation at 60% evapotranspiration has produced equal yields as 90% ET. Environmental benefits, such as erosion control and improved soil and water quality, could also increase the overall value of conservation production systems.

- Vernon research in the region has shown that no-till results in a 78% reduction in sediment loss, as much as 52% increase in water infiltration, and three times lower losses of nutrients such as phosphorus and ammonium. Enterprise budgets for the Texas Rolling Plains indicate a $23.47 per acre advantage for no-till wheat production versus conventional wheat production. For the 30,000 no-till acres in Wichita County, a savings of over $710,000 could be realized.
Vernon researchers are taking the lead to determine and develop management practices for successful implementation of cover crops. Soil moisture is the top concern for producers in semi-arid environments and a top hindrance to adoption of cover crops. Research has shown that cover crops can significantly lower stored soil moisture entering the cash-crop growing season (cotton and wheat). However, subsequent cotton yields have not been affected, indicating that soil health may be improving where cover crops are implemented. Producers should realize that a long-term commitment must be made to truly weigh the benefits or consequences of cover crops and or crop rotations.

Vernon scientists are exploring supplemental grazing opportunities that may also provide additional benefits or profits to the producer. Environmental benefits, such as erosion control and improved soil and water quality, could also increase the overall value of conservation production systems.

Cropping systems within the Rolling Plains are predominantly monoculture cotton and wheat systems. There are several warm-season crops as options for rotation with cotton, but cool-season alternatives for wheat have been less viable. Over the past few years, winter canola has become a viable alternative for wheat producers. In 2013, an estimated 40,000 acres were planted in North Texas, which is similar to planted acreage in Kansas and Oklahoma. Research has shown that wheat yields have increased by as much as 30% following canola. However, canola production has been more of a challenge for no-till producers. Vernon researchers are leading research to develop optimum management strategies to maintain the expansion of canola acres in Texas. Research includes winter canola variety trials, planting date, tillage systems, seeding rate, row spacing, and grazing. This work has become a viable resource for Texas and southwestern Oklahoma canola producers.

A cropping system study began in 2014 at Amarillo, in conjunction with the Uvalde Center, to assess the production potential and water use of several types of vegetables with a wheat cover crop as an alternative to classic continuous cereal grains production that have relatively low market value and require high irrigation water use. Preliminary results indicate the region has sufficient heat-unit capacity to integrate cropping systems production with vegetables. However, researchers are concerned that Texas High Plains spring season wind levels may make it difficult to establish vegetable crops.

AgriLife researchers have identified major soil-related issues challenging the viability of row crop production in the Texas Southern High Plains. Continuous tillage, monoculture cropping systems, and an ever-increasing demand for water resources has led to areas in this semi-arid environment of diminishing soil quality and decreasing water quantity and quality. A three-year cropping systems study was initiated in December 2014 aimed at demonstrating and quantifying the impacts of soil health–promoting practices on soil carbon, soil water holding capacity, nutrient availability, and subsequent yield and production economics for deficit-irrigated cotton production. Demonstrations are being conducted at three locations in Texas (Beeville, Chillicothe, and Lamesa), with each of these sites associated with the Texas A&M University System.
Reducing fertilizer and pesticide applications in cotton

- A multi-year study at the Lubbock Center proved that fertilizing cotton with more than 100 pounds of nitrogen per acre did not significantly increase the lint yield but could delay crop maturity, enhance the severity of cotton aphid infestation, and negatively affect cotton quality.

- A study of fruit loss caused by insects in the genus *Lygus* is providing valuable information for cotton producers and is expected to reduce the frequency of insecticide application in cotton production. Lubbock researchers have developed economic threshold and management recommendations for *Lygus* in High Plains cotton. After bolls reached 13 days of age, the insects caused very little seed damage, and any damage did not result in significant lint yield reductions. Once bolls reached more than 28 millimeters in diameter, they were safe from the insects.

- Lubbock researchers also found that under a low water regime (3 inches in season irrigation), cotton lint yield losses from fleahopper damage were more prominent than when 6 inches of water was applied. This indicates that plants under less stress have a greater ability to compensate.

Monitoring water usage by dairies

- Dairy production has expanded rapidly in the High Plains, with the number of milking cows increasing tenfold from 23,000 head in 2000 to 230,000 head in 2012. Given that the rate of withdrawal from the Ogallala Aquifer already far exceeds the rate of its natural recharge, the dairy industry was under pressure from communities and government agencies because dairies were thought to use more water than traditional crops grown on the same land. There was a critical need to have region-specific water-usage estimates for dairies. Amarillo researchers monitored water use at two dairies with differing herd management and manure-handling systems from 2011 through 2013. One is a drylot dairy with 2,660 lactating cows, and the other is freestall dairy with 4,600 lactating cows. Total water usage averaged 11.5 liters and 9.3 liters per liter of milk produced (or 5.6 milliliters per hectare and 8.6 milliliters per hectare of land) at the two dairies, respectively. A workbook model of dairy water usage is being developed from existing models, incorporating the results of this research.
GOAL

Conduct basic and translational research into the factors affecting biological diversity and ecosystem structure and functioning, including the role of human activity.

PROGRESS

- Research scientists at the Vernon Center have developed nationally and internationally recognized, science-based knowledge documenting natural resource management as a requirement for
  - healthy, functional ecosystems;
  - integrated crop and livestock production systems; and
  - sustainable use of natural resources in semi-arid environments.

Researching rotational grazing for ecosystem health

- Vernon Center researchers determined the ecological and economic consequences of managing grazing on semi-arid savanna rangeland stocked with livestock to
  - maintain current ecosystem health,
  - maximize profit, or
  - improve ecosystem health over a 30-year time frame.

- At the Vernon Center, different configurations of multi-paddock grazing strategies in tallgrass prairie were examined using a simulation model. In agreement with fieldwork conducted in the study area, these simulations indicated that multi-paddock grazing, when adaptively managed, can take advantage of positive biological responses and minimize negative responses to livestock grazing if knowledge of these biological responses is incorporated into timely management decisions. Both ecological and economic goals were superior when using optimal management of adaptive multipaddock grazing.
  - Use of the model has presented insights into the response of different combinations of management options that would be difficult or impossible to achieve in field experimentation.
  - Using both field data and simulation approaches in tandem has allowed more complete analyses of the impacts of different management and facilitates systems-level investigation at the scale of rangeland ecosystems.

- Vernon research showed that managing grazing for highest ecosystem health results in earning capacity four times higher than on rangelands with poor ecosystem health.
  - Managing for high ecosystem health is imperative for maintaining ranch livelihoods and the ecosystem services that Texans depend on.
Promoting prescribed burning and herbicide application for brush treatment

- The Vernon Center has provided the most complete published data set in the world related to effects of summer season prescribed burning for mesquite and pricklypear cactus control on rangelands grazed by livestock.
  - This program has published some of the only replicated studies that contrast summer and winter fire effects on rangeland vegetation and soils, as well as effects on mesquite seedling mortality.

- A Vernon Center researcher has developed unique and innovative techniques for low-cost conversion of mesquite woodland thickets to a savanna rangeland, with a low density of mesquite mixed with grasses.
  - These techniques include (1) low-intensity fires that reduce mesquite foliage but do not trigger basal resprouting and (2) low rates of herbicide application to convert mesquite thickets to savanna.
  - These treatments cost less than mechanical treatments and provide cover for wildlife and shade for livestock.
  - In the only study of its kind that is based on field data, the researcher proved that the treatment life of root-killing mesquite herbicides is over 20 years, compared with top-killing herbicides at less than 10 years.
  - Mesquite-grass competition research has found that in average precipitation years in north Texas, mesquite canopy cover must reach 60% before production of cool-season midgrasses and warm-season shortgrasses is cut in half. However, mesquite cover only needs to reach 22% to halve production of warm-season midgrasses, which are the most important grasses for cattle forage. This suggests that the best strategy for treating mesquite may be to treat before cover exceeds 50%, which is the standard practice. This adjustment could result in a two- to fourfold increase in forage production following brush control over the modest increases that are usually experienced.

Controlling invasive species through biological methods

- The control of the invasive shrub saltcedar with ground beetles expanded in 2014 following a widespread outbreak in 2012 and additional new discoveries in the Texas Panhandle, where the species is using precious water resources. Data on use of the carabid beetle to control saltcedar along riverbanks and on rangelands is underway, and its primary use will be to determine the ecological success of saltcedar biological control where saltcedar is rapidly being removed from the habitats.
PROGRESS

Controlling insect pests

• The Zebra Chip program at the Amarillo Center has educated close to a thousand farmers and industry representatives about the disease and recommended management practices. The result is that no devastating epidemic of zebra chip has occurred in the past three years. The most solid evidence of the Zebra Chip SCRI program’s value is the increase in potato acres planted in Texas since the program was developed. When zebra chip first entered Texas in 2000, about 20,000 acres of potatoes were planted each year, half in South Texas and half in the Panhandle region. Soon after the zebra chip program verified the potato psyllid as the vector of the bacterium Candidatus Liberibacter solanacearum (Lso), which causes the disease, team members developed an insecticide program that was rapidly adopted by Texas growers. By 2014, about 30,000 acres of potatoes had been planted, indicating that growers are confident about managing the disease. Using this information, Texas potato growers can remain a viable and competitive industry, with annual economic contributions to the state economy averaging $300 million. The program has been the basis for all zebra chip management programs in the United States.

  ○ Although by 2013, U.S. potato growers were spending more than $10 million on insecticides to control psyllids, the incidence of the disease has been maintained at sustainable levels and the potato industry has been saved. The program saves Texas growers an estimated $23 million to $32 million per year, primarily in the Lower Rio Grande Valley, but also in all western potato-producing regions.

• A plant pathology team at the Amarillo Center has determined that late-season infection of potato by the zebra chip pathogen, Candidatus Liberibacter solanacearum (Lso), will multiply to detectable levels once potatoes are taken out of cold storage. The disease can be detected if potatoes are left at room temperature for one to two weeks.

  ○ This gives U.S. exporters a technique to provide confidence when certifying potatoes for export as disease-free.

  ○ The implications of this study are highly significant for seed production and for growers who frequently experience late-season psyllid infestations and place approximately 85% of their crop in cold storage.

• An Amarillo researcher is trapping Southwestern corn borer and Western bean cutworm adults to develop an emergence model. Corn pest model development continued in 2014, and sufficient data are now available to produce a usable model. Once developed, these models will allow precise prediction of pest emergence and forewarn producers of potential problems. The data could be used for more robust predictions in the future.
Improving wheat

• Major projects are under way at Amarillo to develop superior wheat germplasm lines that can tolerate multiple stresses, using conventional and molecular breeding. Modern cultivars generally have a higher yield and more efficiently use available natural resources. They also have greater resistance to insects and to pathogens such as wheat streak mosaic virus, thus reducing the need for chemical applications. The goal of the TAM wheat breeding program in Texas A&M AgriLife Research is to design small grain cultivars focused on hard winter wheat for specific adaptation areas and management programs in Texas. These cultivars have greater resistance to pathogens and insects, thus reducing the need for chemical applications. Investments in plant breeding have consistently produced between 30% and 60% annual rate of return on plant breeding investments.

• Two new wheat varieties, TAM 204 and TAM 114, were released in 2014. TAM 204 has outstanding potential as a grain, dual-purpose, and graze-out wheat variety with high forage and grain yield, resistance to disease and to greenbug, wheat curl mite, and Hessian fly. With good regrowth after grazing, it could become the dominant grazing wheat grown in Texas. TAM 114 has excellent milling and baking quality, along with high grain yield and disease resistance, and high yield potential in both irrigated and dryland environments. With this and other varieties, Amarillo researchers envision that the High Plains of Texas will be known for high milling and baking quality wheat.

• For the first time ever, researchers are tying disease severity over time to final yield. An Amarillo Center team demonstrated that wheat streak mosaic virus develops across fields during the season so that producers have trouble determining whether additional irrigation and fertilizer will be economically beneficial.

  - This team uses hyperspectral radiometry to help predict how disease severity will relate to final yield, helping growers understand the cost-benefit potential for further inputs.

• TAM 111, TAM 112, and TAM 113 wheat are among the most drought resistant varieties ever developed for the High Plains. A 2012 survey showed that TAM 111 and TAM 112 are still the most popular varieties in Texas, Kansas, Nebraska, and the Oklahoma Panhandle. Growers saw a $4.8 million annual increase in yields when planting new wheat varieties developed at the Amarillo Center.

• These varieties are resistant to wheat streak mosaic virus, which can cause over $10 million in economic losses in the Texas High Plains.

  - Studies at the Amarillo Center showed that this wheat is highly resistant to the virus’s natural vector, the wheat curl mite; therefore TAM 112 is expected to be resistant to all mite-vectored viruses.

  - This finding provides important information to geneticists and breeders in their efforts to identify and deploy genetic resistance to wheat streak mosaic virus and other mite-vectored viruses.
Drought is the most important constraint limiting wheat yields in the Southern High Plains, but the past four years of exceptional drought have provided a tremendous opportunity for research and genetic improvements. Researchers in Amarillo have determined traits within the TAM cultivars that provide drought tolerance. Multiple-year field studies indicated that biomass at flowering is important to maintaining high yield under drought. Selecting cultivars with higher biomass and greater early vigor may be beneficial to wheat management. They further found that newer cultivars such as TAM 111 and TAM 112 use soil water more efficiently than a relative older cultivar, TAM 105, suggesting that breeding advancements have improved plant water use in dry conditions.

- For field phenotyping evaluation, the researchers found that cooler canopy contributed to higher yield in new drought-tolerant cultivars. A crop that is cooler than the air temperature signifies a healthy crop and is associated with increased photosynthesis. Experiments showed that the cooler the canopy, the higher the grain yields. TAM 111 and TAM 112 had up to 5°F lower canopy temperature and 31% more grain yield than other genotypes, suggesting that cooler daytime canopy might be the reason for higher yield in the two drought-tolerant cultivars under drought conditions.

- In greenhouse studies, whole-plant data indicated that TAM 112 produced more biomass and grain yield than TAM 111 under water-deficit conditions during grain filling. Researchers found that many genes associated with metabolic processes and dehydration responses were uniquely regulated between cultivars. TAM 112 had three times more unique responsive genes than TAM 111, which could be a reason that TAM 112 performed better under longer periods of drought stress.

### Improving cotton

- Researchers at the Lubbock Center have enhanced genetic diversity available to cotton breeders through phenotypic screening of cotton collections.
  - Discoveries include genes from a wild Hawaiian cotton that improve fiber quality and yield potential for cotton crops.

- They also developed novel screening strategies for disease-resistance breeding in cotton, including resistance to verticillium wilt and root-knot nematode.

- Lubbock scientists assisted Bayer CropScience, Americot, PhytoGen, and All-Texas Seed in their efforts to breed cultivars that are resistant to root-knot nematode and bacterial blight.
  - This work is critical due to the loss of Temik 15G for nematode control.

- Lubbock researchers tested a new partially resistant reniform nematode cultivar in a Cotton Incorporated project (jointly tested in four states).
  - As a result, GB713 was released for commercial use and should make a significant difference in management of reniform nematode in the future.
• Research at Lubbock developed weed management systems to address emerging herbicide-resistant weed populations.
  
  o Palmer amaranth biotypes resistant to glyphosate were first identified in 2011 and were found in an increasing number of cotton fields in 2014. Weed-management studies evaluating residual herbicides as part of a total management system were identified. A combination of a pre-plant incorporated herbicide followed by a pre-emergence herbicide at planting and a residual herbicide at post-emergence with glyphosate can effectively reduce resistant weeds by using different modes of action.
  
  o These systems have been communicated at grower meetings, in popular press articles, videos, and other reports.

• Lubbock cotton breeders evaluated new transgenic technologies in cotton, including Bollgard II XtendFlex (glyphosate/dicamba/glufosinate tolerant) and Enlist (2,4-D tolerant), for crop tolerance and weed efficacy. These represent promising tools for managing problem weeds as well as glyphosate-resistant Palmer amaranth. Improved control of many problem annual and perennial weeds was achieved in these systems compared to with glyphosate alone. These technologies are expected to be available to growers in 2016.

• Lubbock researchers used interdisciplinary cropping system research to reduce overall insecticide-use frequency in High Plains cotton.

**Improving ruminant health and animal agriculture**

• Through the Ruminant Health project, Amarillo Center researchers have concluded studies that will facilitate development of health, management, and nutritional strategies to improve animal production, animal health and well-being, and food quality and safety in beef and dairy enterprises — while reducing environmental risk factors and conserving natural resources.

  o Included were an analysis of the effect of genotype on uterine health after calving in Holstein cows; a study on the dynamics of culling risk for cows in large multi-breed dairy herds; investigation of the influence of drinking water turnover rate on fecal shedding of E. coli O157:H7 in finishing cattle; a study on the genomic variation in immunity and susceptibility to mastitis in Holstein cows; studies on the use of a botanical treatment for mastitis in organic dairies; a study on bovine respiratory disease risk in newborn beef calves; and a project analyzing the use of an algae by-product for cattle feeding.

  o Given the limited resources for treating disease in organic dairies, researchers are evaluating the effect of natural products on health, survival, and fertility of cows affected by uterine disorders. As organic dairies continue to grow in the United States, they will continue to explore this research.
- Scientists from the Department of Animal Science, the Vernon Center, and the Institute for Infectious Animal Diseases (IIAD) are collaborating to develop a behavioral-based monitoring system using radio frequency identification (RFID) technology for preclinical detection and mitigation of bovine respiratory disease (BRD) in beef cattle. This disease is the most common cause of antimicrobial use and morbidity and mortality in the beef cattle industry, costing over $1 billion annually. Commercial feedlot adoption of active RFID-based morbidity detection for BRD mitigation would also provide enhanced real-time monitoring and surveillance for zoonotic disease outbreaks.

  - Preliminary results have shown that predictive algorithms developed by AgriLife Research to monitor deviations in feeding behavior metrics can accurately detect BRD cases two to three days before clinical symptoms are observed.

  - Ongoing efforts by the research team include further validation of the behavior-monitoring technology, refinement of predictive algorithms, and development of managerial decision-support systems.

- AgriLife Research and USDA’s Agricultural Research Service have collaborated to develop a non-GMO novel probiotic bacteria that can hyperutilize ruminal nitrate and nitrite that markedly reduces the risk of nitrate poisoning in cattle consuming toxic levels of nitrate through feed or water. Increasing drought will lead to increased threat of high-nitrate forages being grazed or fed as hay. The new probiotic has been effective both in the lab and in living animals in rapidly reducing nitrate and nitrite toxicity.

  - Additional benefits attributed to the probiotic are reductions in rumen methane production and antimicrobial activity against some food pathogens.

  - The probiotics are currently under patent evaluation and commercialization review.

- In Vernon Center research, the rumen metagenomes of Angus and Brahman cattle fed very poor quality hay and supplemented with different protein sources were found to differ in rumen bacterial community composition and functionality. Observed differences point to genetic and environment interaction that supports pursuing further research into the host-microbiome interrelationships to enhance production efficiency in the two most important biologic types of beef cattle in Texas and throughout the South.
Developing new drought-tolerant, cold-tolerant, disease-resistant hybrids

- Adoption of drought-tolerant wheat cultivars is an important practice for producers in the Texas High Plains.
  - Amarillo researchers found that two newly released wheat cultivars are consistently more drought tolerant as compared to some older, drought-susceptible cultivars.
  - These findings help researchers to identify some important physiological traits and molecular markers conferring drought tolerance and use these traits in breeding wheat cultivars for improved drought tolerance, yield, and water-use efficiency.

- Corn is the major irrigated crop in the North Texas High Plains, and corn irrigation uses 53% of the entire water budget annually in the region. Amarillo researchers have evaluated new drought-tolerant corn hybrids at three irrigation levels in the region. Multi-year field studies indicated that it is possible to maintain 200 bushels per acre of yield at an irrigation level of 75% of evapotranspiration (ET) requirement with some new hybrids. This irrigation level can allow water savings over 20%. Water-use efficiency is generally maximized as well. In the north Texas Panhandle, saving irrigation just 1 inch per acre per year on all the regional corn acreage would result in a total water savings of nearly 40,000 acre-feet, or 13 billion gallons. The overall economic return will be easily multiplied by adding the savings in pumping and other production costs.

- In 2014, Amarillo researchers found that a new drought-tolerant corn hybrid has the ability to use more water in the deeper soil profile, which can boost effective use of soil water under drought. This is an important trait for crops to combat drought stress in semi-arid environments. In another study, they evaluated corn hybrids with differing maturity dates on different planting dates, with a goal to maintain yield and maximize water-use efficiency. The two-year results indicated that proper late planting (early to mid-June versus early May) with short-season hybrids (96-day corn) may provide some benefits for corn production, such as saving irrigation water because of better chance of rain, possible re-planting after hail damage, and other flexible field operations.

- New multiple-stress-tolerant corn germplasm from the Lubbock Center's corn breeding program can broaden genetic diversity; reduce the risks of yield and quality loss due to drought, high temperatures, and insects; reduce aflatoxin contamination; and save water. The lines are being used to produce commercial hybrids in Texas and also in Turkey. Licensing agreements have been signed with both U.S. and international seed companies for evaluations.
A Lubbock corn breeder coordinated the nationwide project for breeding aflatoxin-resistant corn. Other investigators in the project include scientists from Texas A&M University and from USDA’s Agricultural Research Service in Mississippi, Georgia, and North Carolina. They have identified new sources of aflatoxin-resistance germplasm.

Pre-nucleus seed of an early-maturing ryegrass line and a hybrid orchardgrass line was produced at the Vernon Center in 2014. The early-maturing selection needs improvement in persistence, and further selection and evaluation are planned.

Thirty-eight unique hibiscus lines were identified at the Vernon Center in 2014, and a successful method to propagate hibiscus from stem cuttings was developed to enable production of many copies in a relatively short time for evaluation by commercial partners. Five new evaluation agreements were initiated with private industry partners. About 1,000 new hibiscus hybrids were made during 2014; approximately 30% of them will be evaluated in 2015.

AgriLife researchers have conducted multi-year field studies and evaluated different methods to quantify canopy temperature depression as a good indicator of drought tolerance.

- These methods include continuous infrared thermal meter (IRT), handheld IRT, and thermal imaging.
- Continuous IRT and thermal imaging appear most promising in quantifying the differences in canopy temperature depression among wheat lines.
- Researchers also developed software to precisely calculate the plant canopy temperature by filtering soil background.
- These tools can be used to evaluate plant response to other stresses such as heat, plant disease, and weed competition.
- They also can be used in other crops such as corn, sorghum, and cotton for screening biotic and abiotic stress tolerance.

Feeding cattle with distillers grains

- One-third of all U.S. beef cattle are finished within a 150-mile radius of Amarillo. The goal of the Texas A&M AgriLife Research Beef Cattle Nutrition Program at the Amarillo Center is to improve beef production efficiency and animal health while
  - reducing nutrient losses to the environment,
  - conserving natural resources, and
  - improving the quality of beef delivered to the consumer.
- Use of distillers grains in finishing systems is a major focus of the program.
  - Including distillers grains at 20% of dietary dry matter increases the crude protein and phosphorus content of feed.
  - In diets containing distillers grains, a portion of steam-flaked corn can be replaced by dry-rolled corn or finely ground sorghum.
  - Combining two grain sources results in improved average daily weight gain.

- Amarillo researchers continue to study the digestibility and feedlot-performance effects of feeding cattle sorghum wet distillers grains treated with enzymes mixed into a finishing diet of steam-flaked corn. Recent results indicated few differences in digestibility, ruminal pH, performance, and carcass measurements between the group fed with the distillers grains with enzymes versus the control group. Treating the distillers grains with a buffered enzyme complex had positive effects on digestibility, but no corresponding improvements in performance were detected. Further research with increased cattle numbers is warranted.

- In Vernon research, feeding steers dry-rolled corn, steam-flaked corn, and wet distillers grains plus solubles supported markedly different composition in the rumen microbiome. Notably, differences in rumen microbiome composition correlated well with differences in animal performance on these diets. These results point to the need to explore development of targeted probiotic supplementation for feeders receiving markedly different finishing diets.

**Enhancing specialty crop production**

- Lubbock Center researchers have enhanced small-acreage specialty crop production by increasing use of high-tunnel plasticulture in Texas.
  - This technology provides season extension and adverse-climate protection.

- Lubbock scientists improved and protected specialty crops from invasive weeds and potential herbicide drift through development of weed-management strategies.
PROGRESS

Studying the impact of land-use changes on greenhouse gases and carbon

- Vernon researchers are investigating the impact of land-use change on energy, water, carbon, and greenhouse gas fluxes associated with changes from conventional, continuous cotton systems to second-generation biofuel feedstocks (biomass sorghum and perennial grasses) in the Southern Cotton Belt region. Results indicate significant differences in carbon exchange, evapotranspiration, and energy fluxes of cotton compared to biomass sorghum and Old World bluestem grasses. Surface energy balance closure was approximately 90% in biomass sorghum and perennial grassland sites. In the cotton field, the closure was approximately 100%. In the cotton field, most of the available energy (net radiation) was used for evapotranspiration. In the biomass sorghum field, 50%–80% of available energy was used for evapotranspiration. In the perennial grassland, this ranged between 20% and 50%, depending on the soil-moisture conditions.

Researching prescribed burning and ecosystem carbon balance

- Prescribed burning of agricultural lands is under scrutiny because of carbon dioxide emission on combustion. A Vernon Center researcher has studied the effects of prescribed burning for brush control on carbon loss and carbon sequestration.
  
  - Repeated fires, either in summer or winter, were not found to reduce total soil carbon but were found to increase it in some treatments.
  
  - Using carbon dioxide flux towers, the researcher found that the amount of carbon lost to the atmosphere from combustion during a winter fire was recovered through increased photosynthesis by vegetation during the first growing season post-fire in both a wet and a drought year.
  
  - Prescribed burning of rangeland for brush control in Texas will likely not contribute to global atmospheric carbon dioxide concentrations and may actually increase carbon sequestration.

Developing data on mesquite water use and carbon sequestration

- A Vernon researcher has conducted some of the earliest research that quantified mesquite water-use patterns, including water uptake by roots and leaves and root growth responses to drought.
  
  - These data sets have helped scientists understand the true impact of rangeland shrubs on the landscape regarding water use, competition, and carbon sequestration.
GOAL
Create economically feasible, sustainable alternative energy systems through basic and translational research in feedstocks, logistics, and conversion technologies.

PROGRESS

Developing bioenergy from lignocellulosic plants

- High-biomass and photoperiod-sensitive sorghum (PSS) has been identified as a potential bioenergy crop. Amarillo researchers have conducted multiple-year field studies and evaluated the feasibility of high-biomass sorghum hybrids under different soil-water regimes. Although high-biomass yield required full irrigation, the biomass sorghum still could achieve high yields (up to 8 tons per acre) under limited irrigation in the Texas High Plains. It may yield up to 6 tons per acre under dryland conditions with about 8 inches of seasonal rainfall.

  - Although PSS can be grown under both limited irrigation and dryland conditions, limited irrigation may be more attractive for sustaining higher biomass yields, given the large variation of seasonal rainfall in the High Plains.

- Vernon and Amarillo Center scientists have pioneered research on the potential of invasive rangeland woody plants such as mesquite and juniper for bioenergy uses. Lubbock research found that greenhouse gas emissions (carbon emitted per acre) for harvesting and delivery of mesquite to the farm gate was 11 times lower than for irrigated sorghum and four times lower than dryland sorghum and dryland switchgrass. Dollar cost per biomass harvested and delivered was twice as high in both sorghum systems compared to either switchgrass or mesquite systems. However, due to a 10-year reharvest schedule, as opposed to annual harvesting in the other feedstocks, mesquite production potential was eight times less than irrigated sorghum, five times less than switchgrass, and three times less than dryland sorghum. Thus, while mesquite appears to be environmentally friendly as an energy feedstock, its significantly lower production potential will limit this feedstock to that of a complementary source rather than a primary source.

  - Researchers found that it would be three times more profitable to harvest only aboveground growth of mesquite and allow regrowth to be reharvested every 10–12 years as an optimum to facilitate both bioenergy and livestock forage needs.

  - Compared to conventional coal, mesquite biomass was found to be a more expensive energy source for electricity production, but a possible carbon emission tax would make mesquite biomass competitive with conventional coal.
GOAL

Model and understand the dynamic relationships among biological molecules to genetically improve production, disease resistance, and environmental adaptability of plants and animals used to produce food, fiber, and bioenergy.

PROGRESS

- Lubbock Center researchers created population mapping for developing thrip-resistant cotton using a resistant line discovered in a screening project. Acres treated for thrips from 2008 to 2012 ranged from more than 69,000 to more than 860,000, at a cost of $2 to $9 per acre. Cost of treatment has soared, and efficacy has declined with the loss of aldicarb and resistance to seed-applied neonicotinoids. Proposed germplasm releases show a 30% decrease in visual thrips damage; these lower treatment thresholds will save up to $2 million per year in treatment costs.

- Plant Release Committee approved CA 3003 and CA 3004 germplasm lines from Lubbock research that produce 9.4% and 7.6% less waste than currently grown cotton, respectively, resulting in approximately a $3 value increase per bale unit and a 54%–69% improvement in yarn quality.

GOAL

Capitalize upon data from high-throughput sequencing, proteomics, metabolomics, metagenomics, and other advanced technologies to develop systems biology tools for improving agricultural productivity.

PROGRESS

**Studying rumen bacteria in relation to cattle diets**

- Researchers at Vernon, Amarillo, and Lubbock quantified and described for the first time, in studies using a single set of cattle, the response of rumen bacteria to diet shifts from warm-season perennial Bermudagrass hay to cool-season grazing on wheat. Using the 16S rDNA gene marker, they identified genera and operational taxonomic units of bacteria in the rumen of cattle on these diets.
  
  o *Using these molecular DNA tools will allow scientists to identify the bacterial species or species groups associated with the onset of metabolic disease and develop interventions to decrease the more than $500 million annual cost of bloat and acidosis in cattle.*

**Exploring genetic selection for disease resistance in cattle**

- Commercial platforms to perform genomewide association analyses have become available and more affordable in the past few years. This technology provides the opportunity to explore vast areas of the genome, complementing traditional breeding strategies for animal improvement.
• Amarillo scientists have conducted candidate gene analyses exploring genetic variation associated with resistance to disease in cattle populations. They have determined genotypes significantly associated with high-impact health disorders, including reproductive diseases and mastitis. Developing applied animal selection practices in disease control is a sustainable approach with significant potential for improving the overall health, welfare, and profitability of food animal producing systems.

  o Progress is being made in the use of new technologies in disease detection, including (1) analysis of the association between animal behavior, tympanic temperature, and hematologic parameters with clinical bovine respiratory disease and growth performance; (2) changes in behavior, activity, and milk yield during the initial phases of disease; and (3) determination of cutoff levels for early intervention.

Using genetic selection for improved livestock fertility

• Researchers at Amarillo are evaluating direct measures of fertility in livestock and performing genomewide association studies using high-density DNA analysis platforms. This research is expected to improve the methods used for genetic selection of dairy cattle and reverse the antagonistic trends of reduced fertility in dairy cows without impairing genetic progress for milk yield.

  o The $2.9 million grant for this project was funded as part of the Translational Genomics for Improved Fertility of Animals program (USDA-NIFA/AFRI program).

Using marker-assisted selection in wheat breeding

• Wheat genetic research has combined available molecular techniques, knowledge, and tools with traditional methods to identify tightly linked molecular markers for marker-assisted breeding to increase selection efficiency. High-throughput, single nucleotide polymorphic markers (KASP SNP) were developed for a greenhouse resistance gene, a wheat curl mite resistance gene in TAM 112, and a wheat streak mosaic virus resistance gene. These markers have been validated and are being used in AgriLife Research breeding programs and many other breeding programs in the High Plains. Private companies from the United States, Australia, and Brazil are requesting these KASP SNP markers.
• The goal of the wheat genetic research at Amarillo is to identify new sources and novel genes associated with resistance or tolerance to drought, rusts, mosaic viruses, and insects. For the past two years researchers have been working to finely tag a gene conferring resistance to wheat streak mosaic virus, with the goal of improving yield and genetic gain through markers for rapid testing of genotypes for resistance to this virus. After genotyping research in 2013 and 2014, molecular markers divided genotypes into two distinct groups corresponding to resistance and susceptibility to the disease. A journal paper covering this work has been prepared and will be published soon.

• Another important wheat genetics study focuses primarily on improving yield by introducing drought tolerance into stem rust resistant lines from Kenya. Phenotyping was conducted under both drought and well-watered environments to obtain data for mapping and select drought-tolerant wheat lines that have no yield penalty when environmental conditions are favorable. Data were collected from seven environments during 2013 and 2014, and genes have been mapped. Crosses between TAM 111 and three spring wheat cultivars from Kenya possessing wheat stem rust resistance have also been made. The crosses are important for potential improvement in yield as well as genetic diversity. They are now being tested in Kenya and the United States under both stress and non-stress environments.

Conducting peanut-breeding programs focused on genetic resistance or insect and disease tolerance

• The Texas A&M AgriLife Peanut Breeding and Genetics program based partly at the Lubbock Center released transcriptome sequences from leaf, pod, and root tissue of a progenitor species of the cultivated peanut. This was publicized as part of the International Peanut Genome Initiative (IPGI), which involves scientists from Texas A&M AgriLife Research, the University of Georgia, North Carolina State University, University of California, and other institutions. A manuscript on the transcriptome sequence is in press.

  o The draft genomic sequence of the same diploid species was released in November by IPGI. Lubbock researchers’ transcriptome sequences were provided to help with determining which genomic sequences are expressed genes.

  o Pending the release of the sequence of the cultivated tetraploid peanut, the diploid wild species progenitor genome and transcriptome sequences are already being used for developing SNP (single nucleotide polymorphism)-based markers in diploid and cultivated peanut.

• Lubbock Center researchers used transcriptome-based SNPs to develop a genetic map of a diploid wild species cross, using the Roche Lightcycler at the Lubbock Center and the Fluidigm Biomark in College Station that was purchased by AgriLife Research and the Texas A&M College of Veterinary Medicine and Biomedical Sciences. This demonstrates that the new gene-sequencing technology can be used to make marker analysis far more efficient.
Breeding better-tasting peanuts

- Seed multiplication of Tamrun OL12 and Schubert peanut cultivars is progressing at the Lubbock Center. Tamrun OL12 is an early maturing, high-oleic runner peanut that was developed because of concern about off-flavors caused by drying of immature runner peanuts under warm daytime temperatures. It has reduced potential for developing fruity-fermented off-flavors. Schubert is a second-generation high-oleic runner peanut, intended to replace the OLin variety. Schubert matures one week earlier than OLin, but yielded 520 pounds per acre more in tests over four years, and shelled two percentage points higher. As do OLin and Tamspan 90, Schubert has some resistance to Sclerotinia blight.

Using remote-sensing and other new technologies to improve agriculture

- Using a remote-sensing technique called spectral reflectance, Amarillo Center scientists can accurately estimate early season forage production in a few seconds. Currently this is a ground-based system, but high-resolution aerial systems will soon be available. They have used this system across their entire wheat-breeding program and will now be able to make rapid progress breeding for increased forage yield in wheat. Continued improvement in forage yields and quality will benefit both stocker cattle operators and wheat producers.

GOAL

Model and understand dynamic relationships among behavioral and economic factors that influence the development and sustainable adoption of new technologies for the benefit of consumers, producers, and society.

PROGRESS

Keeping growers up-to-date on best practices

- Research conducted by the Cotton Improvement Program at the Lubbock Center resulted in recommendation to modify the USDA’s Cotton Loss Adjustment Standards Handbook to remove “stripper” and “picker” variety designations for the Southwest region. This will streamline the adjustment protocol and allow farmers to freely choose the variety they want to plant.

- Lubbock researchers placed information on their website and distributed it at producer meetings that lists rating of the performance of most commercial cotton varieties to verticillium wilt. This heavily used information helps growers make cotton variety decisions if they encounter this disease.

- Lubbock researchers are helping Southern High Plains cotton producers manage nematodes by choosing resistant varieties. Management has become much more difficult with the loss of Temik 15G from the marketplace. Assessment of nematode-resistant varieties with respect to nematode reproduction and yield is important to the producers, and this information is in great demand from both producers and seed distributors.