2020 AgRESEARCH ANNUAL REPORT

A YEAR IN REVIEW

Real. Life. Solutions.™

UTAgRESEARCH
INSTITUTE OF AGRICULTURE
THE UNIVERSITY OF TENNESSEE

AS THE DEAN OF UT AgResearch, a part of the University of Tennessee Institute of Agriculture, I am pleased to present this annual report showcasing the excellent work of our faculty and staff on behalf of the state of Tennessee. It has been a goal of mine to reinstate this longstanding tradition to share the impacts of the research conducted by our faculty and professionals in eight academic departments and on our ten AgResearch and Education Centers located across the state.

In this report, we showcase our impactful work that is enhancing the economic and physical health of our society as well as maintaining our natural resources for generations to come in Tennessee and beyond. From cattle genomics to sustainable forestry, invasive pest management and species preservation, UT AgResearch scientists are working diligently for you.

UT AgResearch will celebrate 125 years of service next year, marking the establishment in 1882 of what initially were called agricultural experiment stations by the university. This was five years before the Hatch Act was enacted by Congress, granting federal dollars for agricultural research. In fact, the first Tennessee Agricultural Experiment Station was the fifth to be created in the United States. Today, UT AgResearch stretches across the state giving our researchers a wide variety of land, soil, and weather conditions in which to study agricultural impacts and to test ideas that will enhance our lives.

Our goal is to live up to our promise of providing Real. Life. Solutions. to all we serve. We appreciate your interest in our work and hope you will gain a greater perspective on how our research benefits Tennessee and society in general each and every day.

Hongwei Xin
Dean, UT AgResearch
University of Tennessee Institute of Agriculture

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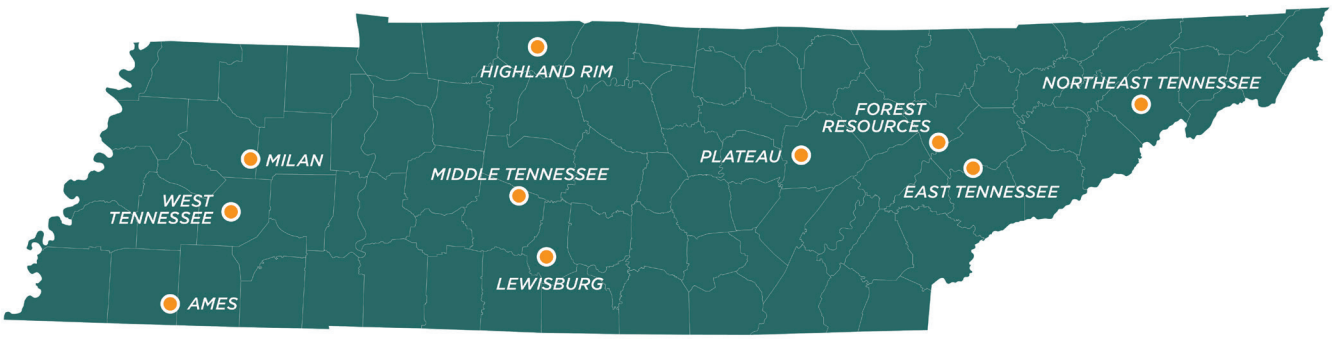
OUR LAND-GRANT MISSION

The University of Tennessee and the Institute of Agriculture are part of the national system of land-grant colleges and universities. Developed in 1862 to educate the next generation of farmers, ranchers, and citizens seeking post-secondary education, land-grant institutions provide excellence in teaching, research, and extension.

When it comes to research, key components of the land-grant system are agricultural experiment stations, enabled in 1887 by the Hatch Act. In Tennessee, the UT AgResearch system includes ten stations, renamed UT AgResearch and Education Centers. These entities are located strategically across the state to enable teaching, research, and extension opportunities representative of the state's diverse agricultural enterprises as well as its soils, topographies, and climate. The research conducted at each Center provides invaluable data-driven discoveries for the betterment of agriculture and natural resources management across the state and beyond.



Key Facts:

- UT AgResearch includes **145 faculty** and **626 staff** (including about **270 graduate assistants/students**) across **eight academic departments** and **ten AgResearch and Education Centers**.
- The diversified and balanced research portfolio supports the **$80 billion economy** related to agriculture and forestry industries in Tennessee.
- Strategic research initiatives and partnerships address current and emerging scientific and social challenges.
- Ten AgResearch and Education Centers on **39,000 acres** conduct approximately **1,000 field trials** each year, including in 2020 in the midst of the COVID-19 pandemic.

  Providing unique outdoor laboratories, these Centers enable problem-solving research and demonstration under real-world conditions as well as timely dissemination of the latest research findings to farmers and allied industries through in-person or virtual field days and technical publications.

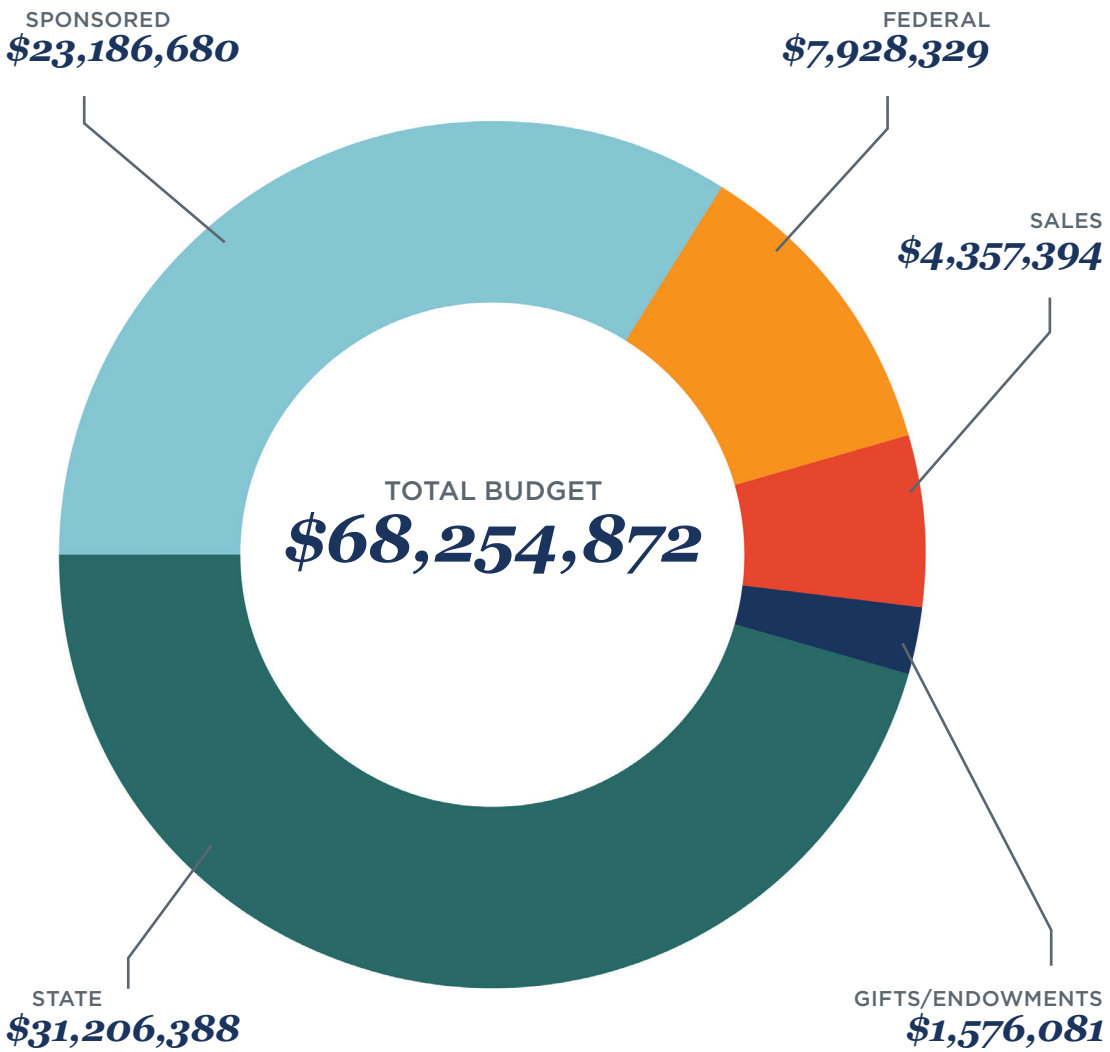
RESPONSE TO COVID-19

No one can deny that 2020 was a year like no other in recent history. COVID-19 affected the efforts of every institution, every work place, and every employee around the world. UT AgResearch was no exception. Here is a summary of our response to the pandemic:

- In March we began to implement procedures to protect the health and well-being of our employees while continuing our mission.
    - Implemented telework. Faculty responded through remote and socially distanced teaching as well as through increased efforts to secure funding for research by submitting 364 proposals.
    - Provided timely supply of PPE (cleaning agents, etc.), including thousands of masks generously donated from friends and colleagues, near and far, especially in the early stage when masks were in short supply.
    - Adapted/developed COVID-19 guidelines specifically for AgResearch and Education Centers and their unique working environments.
- Maintained regular communications with departmental and center leaders, faculty, and staff on and off campus.
- Converted in-person Field Days to virtual format events that reached a broader audience.
- Increased the number of field trials at the AgResearch and Education Centers over the numbers performed in 2018 and 2019.
- Contributed to UT Knoxville Emergency Operations Center (EOC). Associate Dean David White represented research interests in terms of developing and implementing policies on pausing and then resuming on-campus research activities.

FISCAL SUMMARY

In 2020 UT AgResearch operated on a budget totaling more than $68 million, including federal and state appropriations, publicly and privately funded research grants and sponsorships as well as gifts, endowments, and sales of commodities produced on the AgResearch and Education Centers.



IMPACTFUL RESEARCH

UT AgResearch oversees hundreds of research projects that strive to advance the science and technology associated with agricultural production and the sustainability of our natural resources. Many fall under one of four major research initiatives and partnerships described in the followng pages that specifically target key issues. Highlights of a few projects that advanced in 2020 are included.

ONE HEALTH INITIATIVE

Officially launched in 2020, the UT One Health Initiative is a UT System-wide approach housed within UT AgResearch to protect humans and our economic prosperity, which is intimately linked with the health of agricultural systems, communities, and natural ecosystems. Many factors threaten our health, including emerging infectious diseases transmitted by water, food, and insects, and through interactions with livestock, wildlife, and companion animals.

ONE HEALTH
INITIATIVE

OUR MISSION

Preserve and promote human, animal, plant, and environmental health to advance health, increase economic growth, and conserve biodiversity at local, national, and global scales.

In 2020, the UT One Health Initiative advanced in these ways:

- Financial investment by the UT Institute of Agriculture through UT AgResearch, the UT College of Veterinary Medicine, and UT Extension; the Office of the UT Vice President for Research; the UT Knoxville Office of Research and Engagement and the Oak Ridge National Laboratory.
- Time release commitments by the UT Knoxville and UTIA deans to support the One Health scholars from their respective colleges.
- Creation of an external advisory committee for the One Health Initiative (eight individuals) plus internal members as ex-officio members.
- First seed funding issued ($460,000):
    - Transdisciplinary Diagnostic Investigation of Freshwater Mussel Mortality in the Clinch River
    - Socioeconomic Epidemiology of Disease Risk in Wildlife Trade Networks
    - One Health Approach to Controlling *Escherichia albertii*, the Emerging Human Pathogen
    - Developing a System for Molecular Detection and Identification of Zoonotic Pathogens of Most Concern in the USA
    - Developing a Model of Chronic Inflammation to Elucidate Its Effects on Reproduction
    - Impact Assessment of Climate Change on Cotton Production via Computational Simulation

Complete award descriptions and other One Health projects are found online at **UT One Health Research**.

DIGITAL AGRICULTURE

UT AgResearch is investing heavily in "digital" agriculture to enhance producer profitability so US producers can remain competitive in the global market. One example is precision livestock farming, which aims to increase production efficiency, safeguard animal welfare, ensure food safety, improve consumers' acceptance of food products, and reduce agriculture's environmental footprint. An ambitious goal set by the USDA is to increase food production by 40 percent while reducing the environmental footprint of operations by 50 percent by 2030. Precision livestock farming will help achieve this goal by adopting practical innovative technologies that feature automation, artificial intelligence, big-data analytics, machine learning, and real-time monitoring and decision-making. To advance research and extension programs in this area, and to better serve the livestock and poultry industries in Tennessee, an interdisciplinary precision livestock farming team including nineteen faculty and staff has recently been established. The effort is described in detail online at the **UTIA Precision Livestock site**.

Projects currently funded include:

- Development of an Automated Broiler Gait Score and Flock Activity Assessment System
- Evaluation of Heart Rate and Activity in Cattle Using Commercial Sensing Devices
- Genomic Determinants for the Rumen Microbiome
- Implementation of a Novel Biosensor for Early Respiratory Disease Detection in Beef Stocker Cattle
- Improving Health and Well-Being in Broiler Chickens through Environmental Management
- Objective Evaluation of Broiler Welfare and Behavior as Affected by Growth Rate and Stocking Density
- Robots for Reducing and Collecting Floor Eggs in Cage-Free Hen Housing Systems
- Sustainable Precision Dairy Farming: Bridging Animal Welfare and Stakeholder Concerns about the Use of Precision Dairy Technologies
- Transition of Commercially Available Wearable Monitoring Technologies Developed for Dairy Applications to Pasture-Based Beef Cow/Calf Systems
- Utilization of Near Real Time Bodyweight Monitoring to Improve Beef Cattle Reproduction, Health, and Performance
- Utilization of Precision Feeding to Improve Beef Cattle Development, Reproduction, Health, and Performance via C-Lock Smartfeeder Equipment

Photo courtesy the USDA ARS, image k10003-7 by S. Ausmus.

***Hao Gan**, assistant professor in the Department of Biosystems Engineering and Soil Science, is developing a system of multiangle and multirange cameras to monitor commercial broilers at both the individual and flock levels. Using vision software and training, farmers should be able to generate a specific and meaningful animal-based measurement that allows them to enhance raising practices. The metric also should serve as a common assessment tool for food retailers and consumers seeking to support practices that enhance animal welfare. Gan is among six recipients of a Phase I grant from the Foundation for Food & Agriculture Research **SMART Broiler Initiative**, which in partnership with McDonald's, is awarding more than $4 million in grants and technical support to develop automated monitoring tools that assess the welfare of the 9 billion birds raised annually in the US. Increased efficiency for producers is also a goal. Current methods for assessing broiler chicken welfare on farm rely on human observation and subjective scoring.*

AGRICULTURE GENOMICS AND SYNTHETIC BIOLOGY

Two areas of study poised to advance agriculture and natural science research are agriculture genomics and synthetic biology. **The Genomics Center for the Advancement of Agriculture** (housed in the Department of Animal Science) and the **Center for Agricultural Synthetic Biology** (with co-directors from the Department of Plant Sciences and the Department of Food Science) serve as clearinghouses for UT AgResearch efforts in these cutting-edge fields of study.

Through the Genomics Center for the Advancement of Agriculture, UTIA is building a nationally pre-eminent program to provide leadership to the livestock industry, particularly the beef industry, through a holistic approach including animal health, reproduction, structural soundness, disease and pest resistance, heat tolerance, and nutrition and consumer sciences, among others. Efforts have attracted funding from USDA as well as private industry.

***Phillip Myer**, an assistant professor and microbiologist in the Department of Animal Science, as well as a researcher collaborating with the Genomics Center for the Advancement of Agriculture, is leading a study to determine how the rumen—the largest compartment of the cattle stomach—and the microbes that inhabit it affect the conversion of low-quality feedstuffs into usable energy for ruminants. Funded by the USDA National Institute of Food and Agriculture, the $500,000 study seeks to identify whether the genetics of a particular cow influence the rumen microbiome and whether that influence can be passed on to future generations. "The overarching hypothesis of this project," says Myer, "is that host beef cattle genetics are associated with the variation of microbes in the rumen, producing an individualized rumen microbiota among animals." The project has the potential to dramatically advance the field of beef production agriculture to sustainably meet the protein requirements of an ever-increasing global population.*

First announced in 2018, the Center for Agricultural Synthetic Biology is spearheading multiple projects including a $7.5 million effort to use plants to detect environmental threats to deployed troops and help protect civilians living in post-conflict settings. Awarded by the US Defense Advanced Research Projects Agency, also known as DARPA, under its **Advanced Plant Technologies** program, the Center is in its second year of the four-year study. The goal is to innovate a new, revolutionary sensor platform. While the focus of this project is the development of plant sensors for the military, the hope is that advances gained through this and other efforts in synthetic agricultural biology will result in crops that can tell farmers exactly what, where, and when they have problems with pests, water, and nutrients in their fields.

The Center for Agricultural Synthetic Biology is also attracting funding from other agencies and private industry.

ADVANCING A BIOECONOMY

UT AgResearch continues to be at the forefront of research to advance an economy that is based in easily renewable inputs rather than petroleum. A bio-based economy would enhance the economies of rural communities and possibly has the potential to mitigate some of the predicted effects of climate change. Research efforts housed within the **Center for Renewal Carbon**—many of which include partnerships with Oak Ridge National Laboratory, other national research centers, and private industry—continue to receive competitive funding. One example from 2020 is a grant from the Federal Aviation Administration to research the development of **sustainable aviation fuel**.

Photo by John McArthur on Unsplash.

With a $250,000 grant from the Federal Aviation Administration, researchers with the Department of Agricultural and Resource Economics are evaluating regional biomass supply chains with regard to their potential for supplying feedstock for domestic aviation fuel production as well as rural economic development. In particular, oilseed cover crops and softwood logging residues are being studied. Pennycress cover crops may be able to supply as much as 40 percent of renewable aviation fuel for the Nashville International Airport. The analysis includes evaluation of feedstock availability and supply chain requirements to grow, move, and crush feedstock and transport fuel to the airport. Other airport regions to be examined may include Memphis for the oilseed pathway and Chattanooga, Birmingham, and Atlanta for the logging residues pathway.

OTHER IMPORTANT EFFORTS

Many of the efforts of UT AgResearch scientists fall outside our major initiatives, but still serve to advance our mission to enhance agricultural and related industries or to support local, regional, and global efforts to enhance the human condition. To illustrate these efforts, two examples from 2020 stand out.

In one study researchers with the Department of Food Science investigated the chemistry behind Tennessee whiskey. Distillers currently adjust their products' taste empirically throughout the whiskey production process, then rely on professional tasters to sample products, blending subtly unique batches to achieve their target flavor. "By gaining a fundamental understanding of the changes in flavor chemistry occurring during whiskey production, our team could advise distillers about exactly what changes are needed to make their process produce their desired flavor goals," says John Munafo, project leader.

With a three-year, $500,000 grant from a National Science Foundation, faculty with the Department of Biosystems Engineering and Soil Science and the UT Smith Center for International Sustainable Agriculture are working to develop an international research coordination network to support sustainable urban systems. Environmental change, population growth, and accelerating consumption of food, energy, and water resources are creating challenges for urban sustainability worldwide, so the team is collaborating with colleagues from across the university and globally in what is truly a broad, interdisciplinary effort to build a comprehensive global database and network of food, energy, and water (FEW)-focused research. The work should make it easier for leaders of FEW-based research to think more broadly, inspiring outreach, engagement, and multinational transdisciplinary efforts to enhance local and global urban sustainability especially in a world where cities and their surrounding areas generally have conflicting interests in terms of limited food, energy, and water resources.

HIGHLIGHTS FROM THE AgRESEARCH AND EDUCATION CENTERS

UT AgResearch operates a statewide system of ten AgResearch and Education Centers for the benefit of the residents of Tennessee and beyond. Each Center serves as a working farm allowing scientists to test their theories regarding agricultural and forest production and natural resources management. The Centers even contribute to broader studies that might include monitoring the state of our environment, climate studies, and issues involving the global One Health initiative.

Included here are brief summaries of some of the activities of each Center in 2020. While the COVID-19 pandemic curtailed many of the outreach activities, much of the core research continued.

AMES

With an eye toward the future, the research activities at the AgResearch and Education Center near Grand Junction, Tennessee, changed from the name Ames Plantation to UT Ames AgResearch and Education Center. The Hobart Ames Foundation, which oversees the Ames Plantation holdings, will continue to own and operate the approximately 18,400 acres located in Fayette and Hardeman Counties in West Tennessee, and Ames Plantation will continue to be the home of the National Field Trial Championship for All-Age Bird Dogs, as mandated by the Will of the late Julia C. Ames.

MAJOR EFFORTS

- Prior to the pandemic forcing the closure of all activities to the public, the Center completed one field trial in January and the National Championship for Field Trialing bird dogs in February. The usual December field trial was also held with proper precautions and physical distancing.
- Extension personnel gained new skills through an in-service training led by the Department of Animal Science in October.
- Students studying with the UT College of Veterinary Medicine gained hands-on experience as part of a four-day in-residence program in November.
- The Center is home to a new cattle research program led by Justin Rhinehart, associate professor and Extension specialist, and Courtnie Carter, graduate student. The effort examines different artificial insemination (AI) techniques and timing for breeding in December and January. The traditional method of AI breeding involves breeding cows through AI, then turning bulls in with the cows ten days later to breed any that might cycle again. This project will breed the cows through AI, re-synchronize those cows that might not have conceived the first time, re-breed them thirty days later, then turn the bull in ten days after the re-breeding. This research will primarily assist commercial purebred breeders in increasing conception rates of high-dollar cows, thus maximizing utilization of herd cows.

EAST TENNESSEE

The East Tennessee AgResearch and Education Center, which includes 1,968 acres in Knox and Blount Counties, is known for its comprehensive support of the diverse research and teaching programs of UTIA faculty. Topics include turfgrass management; soybean, corn, and wheat breeding; switchgrass production and processing; organic vegetable production; plant disease studies; weed management and control; reproductive management in beef and dairy cattle; row crop and forage variety testing; amphibian disease studies; bacterial pathogenesis; antibiotic resistance; and more.

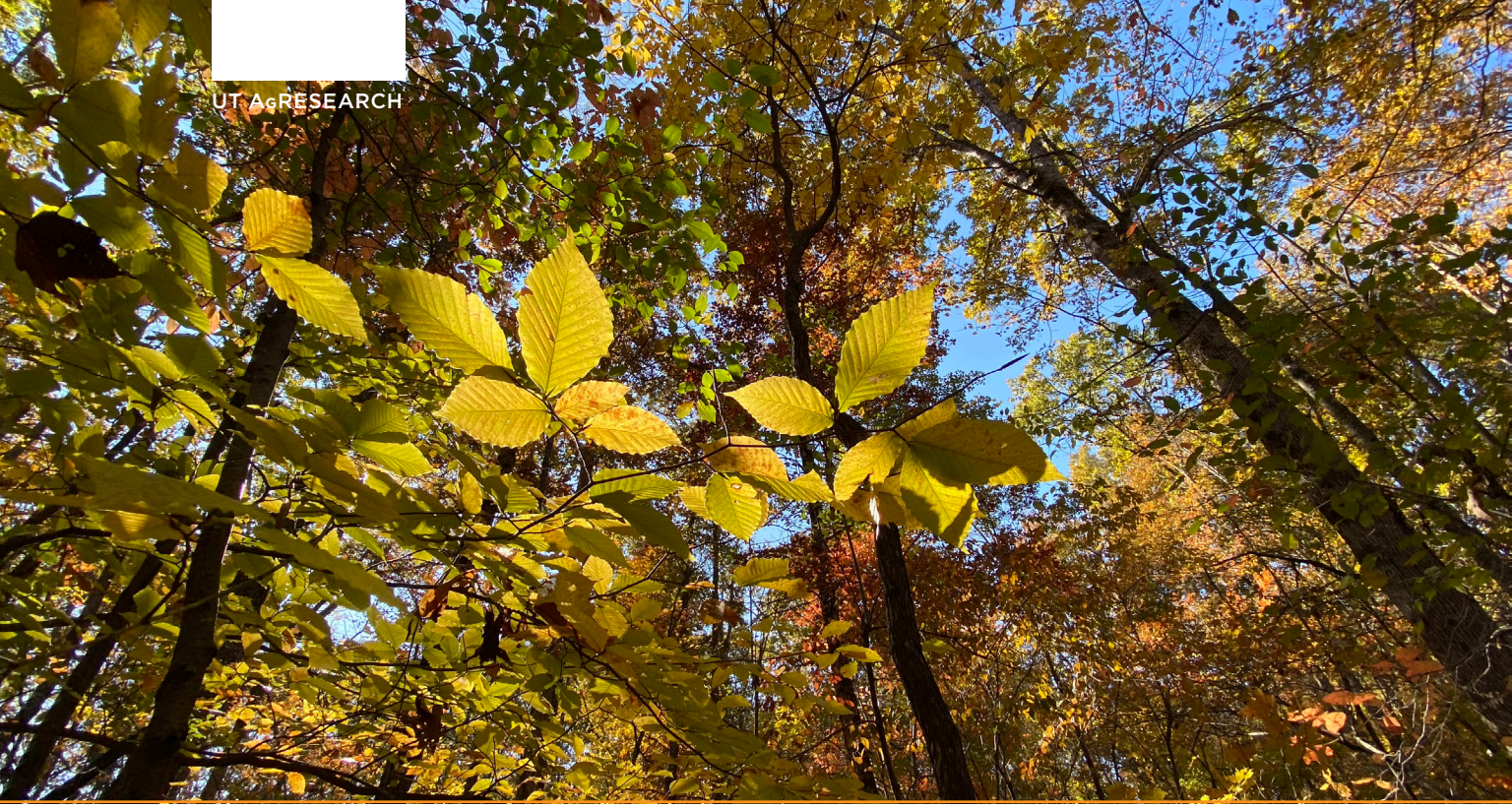
MAJOR EFFORTS

- The Organic Crops Unit reported one of its busiest years since the 91-acre facility was established in 2008. Following a documented three-year transition, eighteen acres out of the twenty-four acres of plot land are Fully Certified Organic. Field activities, inputs, and records are evaluated and approved each year by an official organic certification agency. The remaining six acres are utilized for research involving conventional management practices.
- The following field projects were initiated and/or conducted during 2020. Faculty members participating in these projects represented the Department of Biosystems Engineering and Soil Science, the Department of Agricultural and Resource Economics, the Department of Entomology and Plant Pathology, the Department of Food Science, and the Department of Plant Sciences:
    - Consumer Vegetable Trial
    - Evaluating the Impacts of Seeding Rates in Organic Field Crop Production Systems for Tennessee
    - Agroforestry Systems for Temperate to Subtropical Organic Production Systems
    - Cucurbit Downy Mildew Sentinel Plot
    - Designing Farmer's Goal-Oriented Organic Grain Rotations to Optimize Agronomic, Economic, and Ecological Outcomes in Tennessee
    - Progeny Trial of Native Plants, Hemp, and Pepper Hybrids
    - Gardens for Pollinator Health: How Native Plant Diversity and Quality Affect the Abundance and Diversity of Wild Pollinators
    - Foraging Patterns of Honey Bees

- Comparing Lettuce Yield and Quality Using Drip and Overhead Irrigation on Biodegradable Mulches
- Southeastern Beet Variety Trial
- Squash Hunger: Kabocha squash variety trials
- Also in 2020, the Organic Crops Unit provided land and support for the UT VOLunteer Supported Agriculture (VSA) Program: An Engagement Opportunity for Students and the University Community. This undergraduate internship program provides students with an opportunity to learn about soil management, production practices, organic pest control, harvesting, and marketing of organic vegetables. More than fifty members received a box of fresh produce (all grown at the Organic Crops Unit) from this program once per week for twenty weeks.
- The Organic Crops Unit also cooperated with the Society of St. Andrew gleaners program to provide excess fruits and vegetables to area food shelters and pantries. As of October 30, 2020, almost 7,700 pounds of fresh produce from this facility were gleaned and donated.

UT AgResearch scientists have been awarded a $500,000 grant from USDA to address a common problem faced in Tennessee agriculture: how to effectively transition grain cropping systems to organic systems while decreasing the dependence on intensive tillage. "Organic crop systems typically depend on intensive and frequent tillage operations," states Sindhu Jagadamma, assistant professor in the Department of Biosystems Engineering and Soil Science and lead investigator on the project. "However, most row crop producers in Tennessee follow no-till management practices. Developing viable organic systems that do not heavily depend on tillage can help progressive farmers transition to organic systems." Currently, conventionally grown grains like corn, soybeans, and wheat contribute to 33 percent of Tennessee's gross agricultural income, but the state lags behind in organic production of these same crops. The Organic Crops Unit of the East Tennessee AgResearch and Education Center is one of the study locations.

In 2020, the Center continued with major renovations to greenhouses 3, 7, and 10. The overarching goal of these renovations was to give the researchers the ability to control the environment in which their research is being conducted as much as possible, eliminating as many variables as possible. This will ultimately lead to results and data that are more reliable and trustworthy.



FOREST RESOURCES

Headquartered in Oak Ridge, the Forest Resources AgResearch and Education Center is composed of three forest units located in East and Middle Tennessee: the Oak Ridge Forest, the Cumberland Forest, and the Highland Rim Forest. The Center includes more than 11,400 acres and is a regionally recognized leader in developing new technologies applicable to modern forestry and wildlife resources management and environmental stewardship.

The AgResearch and The Nature Conservancy Partnership on the Working Woodlands Program is the first agreement in the nation between the Conservancy and an academic institution. It provides increased capacity to conduct cutting-edge research to address climate change, best management of forestry natural resources, and training of next-generation foresters and leaders. The project received a 2020 Forest Stewardship Council Leadership Award.

MAJOR EFFORTS

- The Center completed field plot work for the Nature Conservancy–UT AgResearch Working Woodlands Project in Summer 2020. This project will have a direct impact on Tennessee forest landowners/forest industry through improved forest management practices, more efficient use of natural resources, improved environmental stewardship, and greater profitability through an alternative revenue source. The program was successfully shared with interested members of the public and members of The Nature Conservancy via a webinar presented online in October. This was a multidisciplinary team composed of staff from The Nature Conservancy, UTIA, and UT AgResearch as well as private forestry consultants.

- Field work for the Economic Life-cycle Analysis Biomass Logistics Project was concluded in August 2020. The Biomass Logistics project will have a positive impact on the use of forest residuals, transportation of the feedstock, and manufacture of bio-based fuels for the future. This project will have a direct impact on Tennessee forest landowners and the forest industry through change of management practices, more efficient use of natural resources, improved environmental stewardship, and profitability through an alternative revenue source. This involved a multidisciplinary team of personnel from the Department of Agricultural Resources and Economics; the Department of Biosystems Engineering and Soil Science; the Department of Forestry, Wildlife and Fisheries; and the Forest Resources AgResearch and Education Center.

- In collaboration with the UT Arboretum Society, the Center presented the annual UT Arboretum Butterfly Festival as a virtual event in September. Monarch butterflies and other native pollinators are of great concern, and this online event highlighted their importance as well as the perils that are affecting them. This effort included members from UTIA Marketing and Communications, Center staff, and UT Arboretum Society volunteers.

- In October, the Center presented the annual Woods and Wildlife Field Day as a virtual event. Major topics explored included field day research focused on potential forest management of Tennessee native trees and the carbon that is stored within the produced wood. This team was composed of UTIA Marketing and Communications professionals; UTIA Information Technology Services; Department of Forestry, Wildlife and Fisheries scientists and students; and Center staff.

HIGHLAND RIM

The Highland Rim AgResearch and Education Center, established in 1943, includes 615 acres and is known for its research in cow-calf management and dark-fired and burley tobacco production efficiency. The Center conducts cow-calf research emphasizing forage utilization and breeding efficiency and fire and air-cured dark and burley tobacco breeding, management, and curing.

MAJOR EFFORTS

- The Kentucky/Tennessee Tobacco Improvement (KTTI) is a long-standing, world-renown effort managed by Robert Miller, professor with appointments in both UTIA and the University of Kentucky, that is developing new and improved tobacco varieties. The goal of this work is varieties with higher disease resistance, better yield and leaf quality, and reduced levels of harmful compounds found in the cured leaf. This program has produced a number of new tobacco varieties in all three types grown in the state of Tennessee. It is estimated that 70 percent of the burley grown worldwide is one of these varieties or contains the genetic material of these varieties.

    - The increased resistance to diseases such as black shank and blue mold has yielded more pounds of higher quality leaf. In some cases, disease pressure is so high, producers are only able to continue production due to the varieties released by this program.

    - A major goal of the program is to reduce the levels of harmful compounds found in the cured leaf. Much work has been done in recent years, but it will be critical as the industry moves forward under stricter regulations that the levels of harmful chemicals continue to decrease.

    - Funding for this program has been provided by UT AgResearch, Philip Morris International, Altria Client Services, and Japan Tobacco International.

- Renovations to the administration building, first constructed in 1956, were completed to enhance accessibility to the building and restroom facilities for persons with limited mobility. These improvements bring the administrative building into compliance and allows the Center to better serve community members and faculty who use the facility for meetings and events.

MIDDLE TENNESSEE AT LEWISBURG

The Middle Tennessee AgResearch and Education Center at Lewisburg was established in 1929 as a dairy research facility, but since October 2015 it's been home to the Tennessee Beef Heifer Development Program and other research and demonstration efforts to improve beef cattle production.

MAJOR EFFORTS

- The annual heifer development consignment program provides education and an added-value product back to participants. Adoption of recommended production and managerial practices for developing replacement beef heifers—often the most costly component of beef cattle production—can benefit Tennessee producers by improving their production efficiency. Revenues from consignment fees ensure sustainability of the program.

- A study is underway to determining the effects of nutritional plane and level of adiposity (fat deposition) on seminal fluid content, epigenetic profiles, and male fertility in beef bulls. Males contribute half the DNA to the embryo; however, recent findings suggest a much larger impact of the sire during early pregnancy. The exact role of nutrition on the ejaculate composition and function, male fertility, gene expression, and the establishment of pregnancy is not fully understood. This effort should identify genetic changes to sperm from different nutritional levels. The innovative work is in contrast to traditional approaches to improve cattle production that have focused on the gross physical and physiological attributes of the bull. The result should be a better understanding of the epigenetic and molecular impacts of improper nutrition. This work might alter feeding strategies to increase overall beef production while decreasing reproductive inefficiencies. The result could contribute to increased meat output by 2050 to help meet the nutritional needs of the projected human population of nine billion.

MIDDLE TENNESSEE AT SPRING HILL

The Middle Tennessee AgResearch and Education Center at Spring Hill evaluates varieties of commercial crops, management systems, and weed control systems to improve crop production efficiency. Crops studied include fruit and vegetable crops, such as peaches, apples, grapes, and blueberries. Increasingly, the Center is striving to improve beef production.

MAJOR EFFORTS

- Efforts included modernizing the Center with precision livestock farming (PLF) technologies, including monitoring near-real-time bodyweight to improve beef cattle reproduction, health, and performance. These technologies have proven useful at detecting changes related to reproductive receptivity, animal health, and performance in many food animals; however, there is limited data related to use in range beef cattle. The long-term goal is to develop a precision livestock farming showcase beef production unit. UT AgResearch will use this unit to illustrate to beef producers and Extension agents how these technologies can be used and to test new applications of precision livestock farming tools. Specific project objectives include: 1) determine the ability to utilize bodyweight monitoring for detection of cyclicity in heifers and cows on pasture; 2) determine the ability to detect disease in high-risk stocker cattle; 3) utilize bodyweight monitoring for rapid and precise supplement and feed adjustments for developing heifers and bulls; and 4) provide experiential learning opportunities for students, beef cattle producers, and extension agents across Tennessee and the southeastern US.

- The study of corn grown under living mulch systems is new to the Southeast. These systems could benefit the environment and soil health as well as reduce costs associated with mineral fertilization. A study of the benefits of a white clover living mulch production system, started in 2018 and scheduled through 2021, aims to investigate the system's potential in Tennessee and the Southeast.

MILAN

Approximately 195 research projects were conducted in 2020 at the famous AgResearch and Education Center at Milan. The facility is known the world over as the home of no-till production technology. In December, the US Army was authorized to begin the permanent transfer of some 900 acres of the Milan Army Ammunition Plant property to the Center. Although much of the property was previously leased to the Center, the transfer will greatly increase its permanent research capacity as well as expand studies to include forested tracts.

MAJOR EFFORTS

- The first virtual Milan No-Till Field Day took place July 23, 2020. Hosting this event virtually allowed the largest field day in the world dedicated to conservation tillage to proceed during the COVID-19 pandemic. Sixteen research tours encompassing sixty-five research presentations were shared with clientele around the state, nation, and world.

- The Center is participating in field trials evaluating cotton traits of plants grown with a proprietary system with efficacy against thrips and Lygus (plant bugs). Thrips and Lygus are major pests and contribute to significant yield loss not only in Tennessee, but across the Cotton Belt. This problem is being addressed by a proprietary patent owned and licensed by Bayer to be marketed as ThryvOn Technology.

- Researchers are evaluating the liming value (to increase pH) of broiler poultry litter in an unirrigated no-till soybean field at the Center. With poultry production expanding across West Tennessee, the availability of poultry litter (mixture of bedding and chicken manure) as a soil amendment/fertilizer source will be increasing. Studies have shown a slight increase in soil pH after poultry litter applications. If proven in West Tennessee soils, this discovery would reduce the need for liming, thus reducing production costs.

NORTHEAST TENNESSEE

Established in 1932 as the Tobacco Experiment Station and later known as the AgResearch and Education Center at Greeneville, in 2020 this Center changed its name to better reflect the broad community that the location serves. The 522-acre Northeast Tennessee AgResearch and Education Center will still be known for and conduct research on burley tobacco production, but plans are to transition its focus to commodities that are now of more interest to producers in the region, like forage and beef cow-calf production and forestry and nursery products.

MAJOR EFFORTS

- The Center is developing a robust beef cattle stocker operation. In 2020 activities included installing a new Arrowquip Squeeze Chute and adding additional fencing and waterlines around new pastures for beef cattle production.
    - Studies of forages (tall fescue, orchardgrass, and alfalfa) and other grasses such as switchgrass are underway in support of the beef cattle research. One effort is the Biodiversity Grazing Trial.
    - The Asian longhorned tick is an invasive pest of cattle and other livestock, and it has been recently found in Tennessee. The Center is engaged in studies to monitor and deter populations.
- Industrial hemp is among the new commodities to be studied here, including efforts to identify potential pests and diseases of hemp grown in the region.
- Forestry, nursery crops, greenhouse development, and consumer horticulture are also of interest in the region. Studies of loblolly pine, nuttal oak, black cherry, blueberries, rosemary, and mint are among the plants of interest.

Tobacco evaluations and production studies were also conducted in 2020.

PLATEAU

Equal distance from Nashville, Knoxville, and Chattanooga, the Plateau AgResearch and Education Center near Crossville includes 2,100 acres in three locations. The broad-based facility supports research to improve the production of beef, fruits, vegetables, field crops, and nursery crops. Information from the studies is used by small, part-time, family farm operations, and research data from annual fruit and vegetable variety trials inform growers large and small in Tennessee and across the nation.

MAJOR EFFORTS

- The Center is currently conducting four projects for several UTIA faculty and graduate students studying elements of fertility in beef cattle. Two projects are related to the follicle or oocyte:
    - Relationship Between Preovulatory Follicle Status and Oocyte Developmental Competence.
    - Relationship Between the Follicular Fluid Metabolome and Body Condition Score.

      The goal is to understand how production scenarios that reduce fertility affect the follicle and oocyte and ultimately to develop supplements or novel additions to currently available reproductive technologies to remedy the negative impacts of these scenarios.
- Two projects are related to genetic components of fertility:
    - Heritability of Reproductive Trait.
    - Circulating Markers of Fertility in Beef Heifers.

      The goal is to develop ways for producers to identify animals with inferior or superior genetic potential for reproductive success.

- The Center is playing a key role in the development of roses resistant to rose rosette disease, which causes severe economic losses ($70 million annually) for rose producers, wholesale and retail garden centers, professional landscapers, and private homeowners. Tennessee is a national hotspot where losses exceed $2 million annually. The ultimate solution for the rose industry's precarious economic status is the development of rose rosette disease-resistant roses that have desirable horticultural traits such as flower size, color, and fragrance.
- Research at the Center is contributing to efforts to determine how beef cattle genetics affect an animal's ability to transform plant materials into protein fit for human consumption. A team of animal scientists are developing technologies that examine the rumen and gut microbiome, and they are identifying relationships among an animal's microbiomes with its diet, physiology, and genetics to understand how these factors impact feed efficiency. The most recent project uses the GrowSafe individual intake feeding system to feed 400 Angus steers over the next three years. Individual intakes and gains are being recorded along with samplings of blood and rumen contents. Genetics and feed efficiencies will be correlated. These combined microbiome and genetic tools could improve genetic selection for feed efficient cattle.

The Plateau Center is hosting trials of 1,253 rose genotypes, including all of the major rose cultivars grown in North America. They are being screened for resistance to rose rosette disease. Although 96 percent of screened roses have exhibited severe disease symptoms, several Rosa rugosa *cultivars and breeding lines with R.* rugosa *and R.* carolina *heritage continue to exhibit few or no symptoms. Several have been designated as resistant and some are designated as immune. These resistant and immune roses will serve as parents in breeding projects to develop rose rosette disease-resistant roses with desirable horticultural traits. Led by Mark Windham, professor in the Department of Entomology and Plant Pathology, this research involves a collaboration of multidisciplinary scientists (entomologists, geneticists, plant breeders, and plant pathologists) from UT AgResearch, Texas A&M University, the University of Minnesota, and the University of Wisconsin—River Falls. Many corporate plant breeders contributed plants for screenings. UT AgResearch, Texas A&M University, the American Rose Society, and donations by rosarians and rose companies are currently funding this research, which is vital to the future of this important and beloved nursery crop.*

WEST TENNESSEE

Known for its research on agronomic crops as well as ornamentals, turfgrasses, and horticultural crops, the West Tennessee AgResearch and Education Center, established in 1907, is the oldest AgResearch Center in the UT System. Scientists of UT as well as USDA Agricultural Research Service conduct more than 170 investigations annually to evaluate new cultivars and test and develop technology for more efficient crop production and a safer and aesthetically pleasing environment.

MAJOR EFFORTS

- Variety selection can be the difference between turning a profit and losing the farm. This is why the UTIA Variety Testing Programs for Agricultural Crops is vital to the state's producers. The West Tennessee AgResearch and Education Center is front and center in this effort for the state's major row crops. Selecting varieties that perform consistently well reduces the acreage of farmland needed to produce the food and fiber that Tennesseans and the world demand while simultaneously keeping individual farmers in business. Variety testing programs involve UTIA researchers, Extension specialists, and county agents working in cooperation with many public and private institutions that provide varieties for testing. Besides yield and quality metrics, data are collected on how quickly varieties mature, their physical and chemical properties, disease tolerance, and other important characteristics. Efforts are led by UTIA variety trial coordinators and supported by other AgResearch faculty and personnel at AgResearch and Education Centers.

- Variety testing is among the most impactful research programs in Tennessee by increasing yields and producer profits and improving the rural economy. For example, more than 90 percent of Tennessee producers use data collected in corn, cotton, soybean, and wheat variety testing programs to help choose a variety. This number represents nearly 2.7 million acres of cropland that are influenced by this research, and even conservative estimates indicate that this increases farm income by more than $100 million annually and, through multiplier effects, has an even greater impact on the economy of rural Tennessee. Testing programs are also supported in part by grants or entry fees paid by seed companies.

- Researchers at the Center are developing row crop cultivars that will be more profitable for the state's producers. They also are identifying optimum management strategies for production, including improved pest and weed control; improved planting and cultivation techniques; evaluations of foliar and seed treatments; new strategies for irrigation and drought management; and more. Crops studied include corn, cotton, soybeans, wheat, and sorghum.

- The Center is home to the UT Gardens, Jackson, one of the three sites of the State Botanical Garden of Tennessee. Staff conduct annual and perennial variety trials for various flowers, maintain an arboretum, and oversee consumer horticulture educational activities.
- Forest management research and tree genetics studies are also supported by the Center.

Student interns view examples of cotton seedling disease at the West Tennessee AgResearch and Education Center

The USDAs National Institute of Food and Agriculture (NIFA) has awarded nearly $400,000 to provide experiential learning opportunities at University of Tennessee AgResearch and Education Centers in West Tennessee. The Research and Extension Experiences for Undergraduates (REEU) grant will offer agricultural workforce development, as well as research and extension training to prepare students to fill expected gaps in the country's food, agriculture and related industries. The University of Tennessee is one of 26 institutions that received a REEU grant. The focus of UT's summer internship program will be integrated pest management (IPM), an environmentally sensitive approach to pest management. Interns will work directly in IPM programs across all eight research disciplines represented at the West Tennessee AgResearch and Education Center.

NOTEWORTHY ACHIEVEMENTS

In 2020, UT AgResearch faculty and staff were honored for a number of noteworthy achievements through publication of their scientific advances; national and regional recognitions of their excellent efforts and careers; and internal recognition of their work for UTIA and UT Knoxville. The lists below highlight some of their efforts.

Notable Publications

Nature *(43.1)*

Nature Reviews *(23-52)*

Science *(41.0)*

Cell *(36.2)*

Advanced Materials *(25.8)*

Trends in Plant Science *(25:10, p. 947-49)*

ROBERT (BOB) HAYES RETIRED AFTER FORTY-TWO YEARS OF SERVICE TO UT AgRESEARCH

Bob Hayes, director of the West Tennessee AgResearch and Education Center, retired after more than forty-two years with the university, the last eighteen of which he spent as Center director. His departure marks the end of an era: the last of the Tennessee No-Till Team, a group of scientists and Extension specialists whose efforts in the 1970s and 1980s showed farmers how they could park their plows and save their soil.

Institutional and National Awards

American Oil Chemists' Society 2020 Alton E. Bailey Award

Toni Wang

American Society of Agronomy Environmental Quality Section Inspiring Young Scientist

Virginia Sykes

Association of Public and Land-grant Universities Fellow of the Food Systems Leadership Institute

Hongwei Xin and
Neal Schrick

American Society for Agricultural and Biological Engineers Award for Global Engagement

Hongwei Xin

American Society for Agricultural and Biological Engineers Fellow

Alvin R. Womac

Forest Stewardship Council Leadership Award

UT AgResearch historic partnership with The Nature Conservancy

National Conservation Systems Cotton and Rice Conference Cotton Researcher of the Year

Tyson Raper

Internal Employee Honors

Center Directors' Award for Outstanding Support Service

Chris Adcock

Center Directors' Award for Outstanding Professional Service

Brandon Beavers and
Dalton McCurley

J.E. Moss Achievement Awards

William Hart and David White

AgResearch Impact Award

Nicole Labbé

Professional/Academic Award

Kevin Hoyt

Miles Community Service Award

Chad Hellwinckel

T.J. Whatley Young Scientist Award

Nour Abdoulmouminee

AgResearch Mid-Career Faculty Research Excellence Award

Jennifer DeBruyn

AgResearch Dean's Award for Outstanding Service

Barbara Gillespiee

AgResearch Dean's Award for Outstanding Professional Staff

Kimberly Campbell

Institute Professor Award

Carl Sams

Carl Sams is one of two winners of the 2020 Institute Professor Award. The Institute Professor Award is the highest honor presented at UTIA. "During my career, I have been blessed by associations with exceptional colleagues and students with whom I share a passion for research, teaching, and outreach," Sams says. "I tell my students our goal is to help farmers feed and clothe our grandchildren while preserving natural resources for our great grandchildren and beyond. UTIA has made it possible for me to pursue that goal in the midst of creative and hard-working people at every level within the Institute. I am humbled and appreciative to have been awarded this honor."

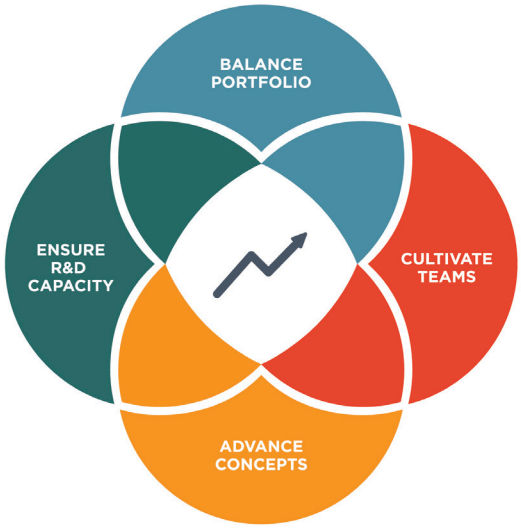
Sams has been with UTIA thirty-six years and is the Austin Distinguished Professor in the Department of Plant Sciences. He also earned the grade of fellow with the American Society of Horticultural Sciences. His research focuses on disease resistance in plants, hydroponics, and mineral nutrition.

INVESTING IN PEOPLE AND ENHANCING RESEARCH CAPACITY

- **UT AgResearch Faculty Fellows program** graduated twenty-nine participants in April 2020
- Approval received to begin construction on the new **Energy and Environmental Science Building**, which will replace the current Ellington Plant Science Building.
- Development of **AgResearch Strategic Action Plan (ASAP)**

  During April to December 2020—thanks to the dedicated work by a team of faculty, department heads, Center directors, AgResearch leadership representatives, and a seasoned external consultant—a three-year **AgResearch Strategic Action Plan** was developed and communicated to the AgResearch community. With its implementation starting in January 2021, the framework aims to position AgResearch to attain the quantitative goals set in the UTIA's *A Decade of Excellence* strategic plan released in 2018.

  The AgResearch plan includes a commitment to support new faculty initiatives, with a goal of four new team initiatives in place by 2024 through an **ASAP SPRINT program**. This new program will include a targeted investment of approximately $1 million in research capacity, progressing through several stages of development. The faculty-driven process will initially involve development of broad, programmatic concepts for review and selection of five to six projects for support. This selection will occur in 2021 and be followed by a six-month period to solidify each research team and build out a research proposal for a second, intensive panel review of the science and potential for sustainable growth. Significant investment will be directed to one or two of the concepts to gather vital preliminary data, establish a collaborative record for the team, and further refine the proposal and business model.



2020 NEW FACULTY AND LEADERSHIP HIRES

CHRIS CLARK

- Professor and Head
- Department of Agricultural and Resource Economics
- 100 percent administration

SCOTT STEWART

- Center Director and Professor
- West Tennessee AgResearch and Education Center
- 100 percent administration

ROBERT WILLIAMS

- Professor and Head
- Department of Food Science
- 100 percent administration

AUGUSTIN ENGMAN

- Assistant Professor
- Department of Forestry, Wildlife and Fisheries
- 70 percent research/30 percent teaching
- Aquatic ecology and fisheries conservation and management

JAMIE GREIG

- Assistant Professor
- Department of Agriculture Leadership, Education and Communications
- 70 percent teaching/30 percent research
- Broadband communications and digital information technology in rural and agricultural settings

BENJAMIN LEARD

- Assistant Professor
- Department of Agricultural and Resource Economics
- 47 percent teaching/10 percent research/43 percent Baker Center for Public Policy
- Environmental and Natural Resource Economics

MI LI

- Assistant Professor
- Department of Forestry, Wildlife and Fisheries; Center for Renewable Carbon
- 100 percent research
- Wood chemistry, biopolymer chemistry, and biorefinery

CHARLES MARTINEZ

- Assistant Professor
- Department of Agricultural and Resource Economics
- 75 percent extension/25 percent research
- Farm and financial management

ALICIA RIHN

- Assistant Professor
- Department of Agricultural and Resource Economics
- 75 percent research/25 percent extension
- Horticulture Marketing

DEBASISH SAHA

- Assistant Professor
- Department of Biosystems Engineering and Soil Science
- 100 percent research
- Soil health and sustainable agriculture

KELLIE WALTERS

- Assistant Professor
- Department of Plant Sciences
- 85 percent research/15 percent teaching
- Controlled environment vegetable physiology

YANG ZHAO

- Assistant Professor
- Department of Animal Science
- 80 percent research/20 percent teaching
- Precision poultry management

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