

## Executive Summary

This report reflects the accomplishments of Research and Extension programs from the College of Agriculture and Life Sciences (CALs) at North Carolina State University (NC State). Our portfolios of cutting-edge, solution-driven research transforms science into everyday solutions that improve lives and grow our state is extended to all North Carolinians through N.C. Cooperative Extension.

From the food that nourishes us and the fiber that clothes us to the ornamentals that brighten our lives and provide ecosystem services – we work on the plants, animals and microbes that sustain us. We live our land-grant mission, supporting individuals, families, communities and businesses in our constant quest to improve lives and provide opportunities for all across our state. We research the basic fundamentals of biology, agriculture and ecosystems; of family and community dynamics; of physics, data and technology; and of educational and extension theory. We turn that basic knowledge into innovation that delivers new technologies, new crops and livestock, new processes, and new ways of addressing challenges on our farms and in our homes, communities and businesses. We bring knowledge to our students and external constituents, and we educate and train the people who make all of this happen. Throughout 2022, the North Carolina Agricultural Research Service (NCARS) and NC State Extension prioritized efforts aimed at solving the complex challenges facing food and agriculture.

## Critical Issue: Improving Plant and Animal Agricultural Systems

NC State researchers are using genetic engineering technology to create better tasting peanut varieties resistant to environmental stresses like drought and disease by fortifying the Bailey cultivar with genetic resistance to late leaf spot, a common, fast-moving disease that costs growers an estimated \$53 million annually. To fight pests, NC State researchers are investigating nematodes' biological characteristics, modeling crop losses in relation to plant-parasitic nematode (PPN) populations and evaluating management methods. NC State researchers conducted studies to determine the population distribution of the brown marmorated stink bug (BMSB) in NC and established an effective model to predict BMSB population development, providing growers with a new tool for precisely timing insecticide applications for maximum efficiency. Researchers and Extension specialists are working on a 29-state project to monitor downy mildew on cucurbit outbreaks, coordinate state activities, identify management solutions, and educate growers on disease management and identification.

Researchers are studying diseases of sweet potato and secured registration for five new fungicides to combat the epidemic of sweet potato black rot, reducing disease losses from 40% to 5% and preventing an estimated \$116 million in losses for NC growers. NC State participates in the National Sweetpotato Collaborators Group, the only national group that focuses exclusively on sweetpotato research and extension activities. The weed Annual bluegrass, known as *Poa annua*, has grown to epidemic proportions, causing severe economic losses. A team of 16 scientists across 15 universities are involved in a four-year project to limit the impact of annual bluegrass, the most troublesome weed of athletic, golf, lawn and sod.

NC State researchers and Extension specialists used applied research and on-farm and official variety testing to develop new varieties, products, technology, and research-based agronomic crop best management practices (BMPs) to support growth in row crop production and assist growers in addressing their technological, biological, and environmental challenges. Extension

specialists and agents transferred knowledge of these innovations and practices to producers. As a result of NC State Extension programs, over 25,000 crop producers increased knowledge, attitudes, and/or skills related to best management production practices; pest/insect, disease, weed, and wildlife management; financial/farm management tools and practices; and alternative agriculture, bioenergy, and value-added enterprises. NC State Extension's commercial and consumer horticulture programs resulted in over 425,000 participants gaining knowledge of landscape, turf, and garden best management practices; over 100,000 participants adopting practices; and nearly 55,000 participants selecting appropriate landscape plants after participating in Extension consumer horticulture programs.

In the area of animal agriculture, NC State researchers have discovered new ways to use animal manure and other animal production byproducts including the use of swine lagoon sludge to create low-cost compost materials, systems for processing lagoon sludge into a compact and exportable form, and the development of a simulation tool to help predict impacts of future climate conditions on animal production lagoons and storage ponds. Extension helped pork producers keep pace with complex and evolving environmental regulations for waste management, by providing assistance with a broad range of tasks, including sludge management, irrigation and litter calibration, record-keeping, manure sampling, general permits, and nutrient management plans. Extension helped pork producers apply for over \$2.7 million in assistance covering lost income, lagoon closure costs, and barn renovation costs. Following Extension training and outreach efforts across the state, over 2,000 producers increased their knowledge of animal waste management practices, 4,583 animal waste management credits were earned, 192 on-site sludge surveys or equipment calibrations were conducted, and 178 waste utilization/waste management plans were developed or updated. NC State researchers assessed the environmental factors impacting broiler behavior and welfare to advance the understanding of how a high air velocity system can help birds regulate their body temperature under hot and humid conditions by releasing excessive heat into the surrounding environment. To address a 2022 uptick in highly pathogenic avian influenza (HPAI) and mitigate harm to NC's nearly \$40 billion commercial poultry industry, Extension collaborated with industry partners to encourage producers to establish and follow strict biosecurity protocols. NC State Extension provided educational programs and technical assistance resulting in 6,975 producers increasing knowledge of pasture/forage management practices, 4,614 producers increasing knowledge of nutrition and breeding, and 5,033 producers increasing knowledge of strategies for promoting animal health and welfare.

### **Critical Issue: Protecting Environmental and Natural Resources**

NC State researchers have analyzed data from natural and agricultural systems that are increasingly monitored through wide-ranging sensors, including those on satellites and installed in the field. Diverse environmental and agricultural datasets have been created using methods such as machine learning and statistical modeling. Advantages gained from this research include the creation of a harvest closure forecasting system and accompanying web application for shellfish producers and the creation of various fact sheets to make data analysis tools more accessible. To help reduce the environmental impact of carbon dioxide, NC State researchers are developing a method to enhance plants' natural ability to pull carbon dioxide from the atmosphere. In addition to benefiting the environment, this method has the potential to increase the growth rate of biofuel and food crops.

NC State researchers have advanced the field of ecology by identifying models that can anticipate the ecosystem consequences of changes in species' communities and developing models to predict territorial spread and competition among species. Researchers have also

provided proof-of-concept for a new method to accelerate the biological recovery of stream-dwelling insects, assess restoration success, and import restoration techniques to freshwater fisheries.

NC State Extension agents offered a variety of programs addressing issues related to environmental protection. As a result of this programming, 13,696 participants demonstrated increased knowledge of climate mitigation practices, and 3,677 participants expressed a willingness to adopt conservation actions. Specialists continued collaboration with University of Maryland on a joint presentation to the Southern Extension Economics Committee on solar development and decommission. In partnership with the NCDA&CS, Extension Pesticide Schools served a total of 1,455 attendees. Extension also led efforts to counteract the environmental effects of extreme rainfall, reduce stormwater runoff pollution from growing communities, and support urban sustainability and water quality. Extension trained and certified 5,465 individuals, including over 20 HOAs, in stormwater control measure inspection and maintenance. Extension's Forestry program educated more than 95,901 landowners, land managers, and other community members across the Southern US about the importance of prescribed fire in forest management, and 37 landowners and professionals learned practical skills to better protect the forests around their homes from wildfires. Forestry programs in 2022 increased the knowledge of approximately 115 Extension agents and agency partners on forest health through 3 workshops in the Carolinas. Extension Forestry also continued to conduct forest health programming to increase knowledge of invasive species. These outreach efforts helped over 235,000 people increase their awareness of the impact of invasive species on local forests.

### **Critical Issue: Enhancing Food Safety, Nutrition and Health**

NC State researchers are developing and using CRISPR-based gene editing technologies to study and modify bacterial strains and develop novel technologies that enable genetic manipulation of food microbes for use in fermentation and as probiotics. Researchers also conducted studies on consumer insights and the sensory quality of plant-based dairy alternatives (PBDAs) and dairy products with reduced sugar and that offer immune-boosting and calming effects. Research found that taste remains the driving force for consumer preference, and the use of a natural low-calorie sweetener that delivers the sensory experience of sugar is more important than familiarity with the sweetener. Researchers from NC State worked to address the problems caused by conventional food processing which degrades flavor, color, quality, and nutritional value. Researchers developed a new, energy-efficient microwave heating technology, followed by packaging into flexible, sterile packaging. In 2022, two processing facilities employing this technology were constructed and put into operation, one in NC and another in Kenya. In addition to maximizing the preservation of sensitive flavors and nutrients and extending shelf life without refrigeration, this technology minimizes or eliminates food waste and reduces processing time and costs. NC State researchers invented a new process for infusing fruit flavors and nutrients into coffee beverages to enhance the quality of coffee products. They also demonstrated the effectiveness of a new microwave coffee extraction method and are investigating sustainable, low-water-use methods of coffee production. In addition, researchers completed a clinical trial on the effects of coffee on blood sugar regulation, and they completed a joint clinical trial with Elon University examining the effects of coffee and coffee roasting methods on athletic performance.

To promote health and wellness, prevent chronic disease, and increase access to healthy foods, NC State Extension delivered a combination of research-based direct educational programs and policy, systems and environmental change efforts. Extension faculty participated

in a national Policy, Systems, and Environmental Change (PSE) collaborative group with other Extension Health Specialist to discuss how to better implement PSE changes through extension across the U.S. The group is working to better understand whether agents are adopting PSE changes, what training they need, and programmatic needs to better support implementation of PSE changes to support access to healthy foods and places to be active.

As a result of NC State Extension programs, 59,225 adults increased their fruit and vegetable consumption, 6,328 increased their physical activity, and 3,924 consumed less sugar in their diet. To also assist with promoting healthy diets and to reduce instances of foodborne illness, NC State Extension developed resources and provided training on food preparation and food safety. As a result, 20,693 participants increased their knowledge of how to prepare foods, including home food preservation techniques and 22,632 participants increased their knowledge of safe home food handling, preservation, or preparation practices. NC State Extension specialists are working to establish a Food Safety Extension Network of institutions across the southeast to synergistically advance the science of consumer and retail/food service food safety and share expertise, training, and developed materials across the Land-grant system. Collaborators include institutions from the southern region.

### **Critical Issue: Enriching Youth, Family & Community Well-Being**

To strengthen local food systems, NC State researchers and Extension specialists trained Extension agents in topics related to healthy eating, cooking, food safety, and local food systems, who in turn trained 135 county-level volunteers who provided 1,922 service hours valued at \$57,564, reaching almost 12,000 community members. In addition, 5 counties launched the Donation Station program, and 2 counties continued the program from 2021, facilitating donations of healthy local food to food-insecure families while supporting farmers through the purchase of 4,459lbs of local food.

To support rural development, Extension specialists and agents supported local development committees in local economic development assessment and planning. They also presented workshops on developing and improving agritourism and other tourism businesses and the use of tourism marketing platforms. To support organization and community development, Extension specialists and agents built organizational capacity to accomplish goals through training and technical assistance in strategic planning, governance, and facilitating complex decision making. CREATE BRIDGES is facilitating strategic plan development and implementation in the mountain west region of North Carolina as part of the national pilot of the CREATE BRIDGES program. Other states participating include New Mexico, Illinois, Arkansas, Kentucky, and Illinois.

Extension professionals also delivered an array of programming to assist individuals and families. As a result of participating in NC State Extension programs, 7,400 people gained knowledge and/or skills to increase family economic security. In addition, nearly 2,500 adults increased knowledge of life skills, such as goal setting, stress management, self-care, and healthy relationships. Extension provided programs for older adults to help reduce falls and help them age in place and improve their strength, flexibility, and balance. Specialists are participating in the Healthy Homes Partnership; a national collaboration between NIFA, USDA, and Extension. States in the partnership include North Carolina, Florida, Georgia, Alaska, Connecticut, Louisiana, Montana, Missouri, Tennessee, and Oklahoma. As part of this initiative, NC State partnered with University of Georgia Extension on Portable Generator Safety Training. This multi-state effort is a direct result of the Healthy Homes Partnership and is an effort to address common issues for those in the Southeast. NC State researchers have discovered insights into potential new approaches to controlling bed bugs and cockroaches. They

discovered that cockroaches are highly susceptible to fungal infections and developed a deeper understanding of why cockroaches rapidly evolve high levels of resistance to some insecticides and not others. Researchers analyzed bed bug production of histamine to better understand the health risks associated with histamine and support potential mitigation approaches.

To help youth develop life skills that will prepare them for future success, NC State Extension provided 4-H Youth Development programs that focused on civic engagement, healthy living, and STEM. For example, North Carolina 4-H focused on educating youth on the importance of voting. 4-H promoted the Kids Voting NC program to create lifelong voting habits in children, increase family communication about citizenship, and encourage greater adult voter turnout. Youth across NC also participated in livestock, poultry, and small animal shows and judging; 4-H projects; and clubs among many other animal science programs. Statewide, Extension youth animal programs had over 26,000 youth participants. In collaboration with Kentucky State University, University of Florida, Mississippi State, Georgia Southern University, and Middle Tennessee State University on STEMSATIONAL AG, Extension specialists are producing both formal and non-formal agricultural educational content for K-14 students that is appropriate for traditional school settings, as well as accommodate distance, in-person, and homeschooled children in the Southeast Region. NC State specialists have served on the management team for the Volunteer Conference of Southern States, a regional 4-H volunteer-led training event featuring a hybrid delivery of more than 60 learning experiences over the four-day experience. 4-H specialists are also members of a national collaborative team working towards providing leadership, organizational alignment, professional development, and advancing the research for the 4-H Thriving Model.