Ava and Ben live in an urban area in the Midwest of the United States. Like many in their circle of friends, they have concerns about the impact of agriculture and food production. They want to learn more about the relationship between food production and climate change. They also want to be sure livestock are cared for and natural resources like water, soil and forests are used sustainably.

Even though they are not directly involved in farming, they are interested in having a closer connection with farmers and the food they buy. They enjoy visiting their nearby farmer’s market and try to eat fresh, healthy food while considering price as well.

Ava and Ben are indicative of the growing and diverse consumer demand that is driving dramatic changes in the food and agriculture system. Many consumers buy in bulk and are focused on getting the best price for safe, nutritious food. Other consumers want fresh and prepared foods in single-portion containers, and many are reading labels and asking about ingredients and production methods. A growing number of consumers are concerned about the environmental and social impact of agriculture and food production, and want to understand more about farming methods and the food they eat.

Forging new relationships and conversations between consumers like Ava and Ben and farmers like Jerry and Emma helps close the “trust gap” that exists in many countries today. Farmers, agribusinesses, consumers and the government must seize opportunities to discuss how productive farming systems contribute to food security while realizing the sustainable agricultural imperative.

Jerry’s farm in the U.S. Upper Midwest consists of 1,200 acres planted with alfalfa, corn and soybeans, along with cover crops. He owns 800 of these acres and rents 400 acres as part of a cost-effective strategy to expand his production.

During the 1980s downturn in the farm economy, Jerry witnessed the hardships experienced by his neighbors. As a result, he has focused on managing risks by diversifying the crops he grows, improving the quality of his crops and livestock and by adopting science-based innovations that help him manage costs while increasing his yields.

Jerry sells most of his crops to grain handlers, but he uses some of the crops grown on the farm to provide feed for his expanding pork operation, managed by his daughter, Emma. Today his focus is on practicing restorative farming to conserve soil and natural resources, diversifying his operations to reduce risk, and building a stable, sustainable business that he can leave for Emma and her family in the coming years.
CROP PRODUCTIVITY BUILDS THE FOUNDATION FOR SUCCESS

The high productivity of Jerry’s alfalfa, corn and soybean crops derives from decades of collaborative research on the part of the federal and state governments, agribusiness companies, entrepreneurs, land-grant colleges and universities and extension agents — and most importantly from farmers like Jerry who take risks and adopt innovative, science-based and information technologies on their farms such as new seed varieties and precision agriculture.

Over the past 30 years, Jerry has worked closely with extension agents from the state university and with private-sector companies, as well as crop and farm advisors and agricultural retailers. They have helped him gradually boost the yields and quality of his products and adopt proven practices in conservation and sustainability.

Innovations in crop genetics, crop nutrients and crop protection products, along with precision agriculture technology on machinery, have enabled Jerry to produce more high-value crops per acre while reducing his business costs and environmental footprint. Widespread

BETTER BREEDING FOR A BETTER FUTURE

For several thousand years, agriculturalists have improved the quality and performance of crops and livestock through trial and error, saving seeds from plants or breeding animals from those that exhibited the desired traits.

Between the 1920s and 1950s, breeders significantly improved crop yields by creating hybrid (cross-pollinated) crops. When the structure of DNA was discovered in 1953, plant breeders were able to more precisely change a plant through modern biotechnology by either introducing a trait from a wild relative of that crop or from another species, or by altering the plant gene itself.

Today, the tools used by agricultural breeders have evolved through science-based innovations. With an ability to understand the genetic sequence of plants and to link a particular gene with a specific plant characteristic, breeders can quickly and efficiently improve plants while avoiding the transfer of unwanted genes.

In the past decade, new gene-editing techniques such as CRISPR-Cas\(^1\) have become available, unlocking potential benefits for farmers, consumers and the environment. Breeders can now edit genes by turning on or off various genetic functions that increase crop yields during drought, protect the plant or crop against viruses and pests (reducing the amount of pesticide needed), improve the nutritional quality and content of crops or help vegetables maintain longer shelf life. Gene-editing technologies such as CRISPR-Cas rely on natural processes that happen in the genome, but channels and targets those changes more precisely.

Seed companies are exploring how this technology allows breeders to develop better hybrids by quickly finding and leveraging the inherent diversity existing in crops.

DuPont Pioneer has developed a higher yield gene-edited type of corn (waxy corn hybrids) useful for many industrial processes. This corn will be available for farmers to use after field trials and regulatory reviews are completed.

To fight a devastating corn disease affecting small-scale farmers in Africa (maize lethal necrosis), DuPont and the International Maize and Wheat Improvement Center (CIMMYT) have formed a public-private research partnership using CRISPR-Cas technology.

Plant breeding innovations like CRISPR-Cas will only be achieved through active engagement and collaboration with farmers, academia, governments, NGOs and public research institutes, both in the United States and around the world.

(continues on page 23)
CROP PRODUCTIVITY BENEFITS THE U.S. AND THE WORLD

The United States is the world’s largest corn producer and currently exports between 10 and 20 percent of its annual production.³ Corn is the most widely produced feed grain in the U.S. and is also processed into a range of food and industrial products.

Between 1980 and 2015, corn yields in the U.S. improved by 61 percent. When measured per bushel produced, corn productivity also improved: land and energy used in corn production each declined 41 percent, irrigation water declined 46 percent, greenhouse gas emissions (GHG) declined 31 percent, and soil erosion declined (tons of loss per acre) by 58 percent.³

Processed soybeans are the world’s largest source of animal protein feed and the second largest source of vegetable oil. The United States is the world’s leading soybean producer and the second-leading exporter.⁴

Between 1980 and 2015, soybean yields in the U.S. improved by 29 percent. When measured per bushel produced, soybean productivity also improved: land used in soybean production declined 40 percent, irrigation water declined 32 percent, energy use declined 35 percent, greenhouse gas emissions (GHG) declined 38 percent and soil erosion declined (tons of loss per acre) by 47 percent.⁵
The use of these innovations by U.S. farmers has resulted in lower prices of food, fiber and biofuels for consumers.

Since he gradually began taking over the family farm operation from his parents in the 1970s, Jerry has increased the size of his farm and diversified the crops he grows to manage risks when weather or crop prices pose a challenge.

In addition to corn and soybeans, Jerry grows alfalfa and oats as part of a crop rotation strategy. Alfalfa provides high-protein forage for livestock and when planted in a field rotation before corn, it fixes substantial amounts of nitrogen in the soil that can be utilized by the corn plants.

During the 1980s, Jerry was able to increase his farm size by purchasing land when prices were lower. Due to higher land prices today, he accesses additional farm acreage through a contract rental arrangement with a real estate investment company, enabling him to free up capital for purchases such as precision agriculture equipment or to invest in his daughter’s pork production enterprise.

(continues on page 25)

RENTING LAND, REDUCING RISK

As the population of the United States increases, urban development and suburban expansion into prime lands used for agriculture takes place. Conversion of farmland and forests for human settlements reduces land available for food and timber production, and releases carbon sequestered in soils.

By 2030, the world will lose 1.8% to 2.4% of highly productive croplands due to urban expansion.6

More than 24 million acres of U.S. agricultural land were developed for other uses between 1982 and 2017; it is unlikely that this land will be restored to farming or ranching operations.

U.S. farmland and ranchland is some of the most productive and expensive agricultural land in the world. Many farmers today are unable to expand their operations and gain access to additional high quality farmland, either due to competition from urban development or, in the case of newly emerging farmers, a lack of sufficient capital and access to credit to purchase farmland.

40+ acres of U.S. farm and ranch land are lost every hour to urban sprawl or development.7

Renting land from other landowners or from real estate companies that specialize in supporting farming operations are options for farmers who wish to expand their operations. Contract farming through rental of land allows farmers to do what they do best: grow crops or raise livestock without incurring debt and risk associated with purchasing land.

Institutional land investors such as Farmland Partners Inc. build long-term leasing relationships with farmers and invest in the capital improvements that increase the productivity of farms. As of July 2017, Farmland Partners owns or has under contract more than 154,000 acres located across 17 states, farmed by more than 124 tenants growing more than 30 major commercial crops. Other opportunities to gain access to land are provided by the USDA Transition Incentives Program (TIP), which encourages current landowners with expiring Conservation Reserve Program (CRP) contracts to sell or lease their land to beginning or socially disadvantaged farmers, or to military veterans. TIP provides retiring land owners with an incentive to return land to production in a way that preserves established conservation practices. It also provides beginning and socially disadvantaged farmers and ranchers opportunities to affordably purchase or rent land.

States such as Minnesota are also tackling the challenge by offering a state income tax credit to current landowners when they sell or rent land to a beginning farmer. Organizations like the National Young Farmers Coalition are advocating for more state and federal solutions. Young farmers often mention access to land as a top challenge, and state and federal legislation that incentivizes the transition of land to beginning farmers helps them seize the opportunity to grow food and help rural communities thrive.
FARMERS BUILD SOIL HEALTH TOGETHER

Farmers understand that healthy soils are the starting point for farm productivity and sustainability. When they work together to conduct research and experiment with best practices, farmers become powerful change agents.

Research from U.S. land-grant universities has shown that managing a crop for optimal nitrogen use and productivity also increases soil organic carbon, which in turn boosts crop productivity while reducing nitrogen loss. Nitrogen and phosphorous use has improved corn yield in the U.S. and greenhouse gas emissions are minimized under these highly productive systems, demonstrating the link between productivity and sustainability.

The Soil Health Partnership (SHP) is a farmer-led collaboration initiated by the National Corn Growers Association that brings together farmer leaders committed to improving the sustainability of their farms with a strong focus on soil health and productivity. As of 2017, SHP has a network of more than 100 demonstration farms to showcase best practices.

Together these farmers are testing and measuring farm practices like growing cover crops, implementing conservation tillage (such as no-till or strip-till practices) and managing nitrogen and phosphorous fertilizers to maximize their benefit while reducing negative impacts on water quality.

Research has shown that no-till cropping systems tend to improve soil health over the long run, but the transition from tilling to a no-till system requires a sustained commitment from farmers and education and support from others, as declines in yield may happen in the first years of the transition period. By adding cover crops, soil health can build up more quickly during the transition to a no-till system, thereby restoring higher yields sooner.

While some cover crops are harvested for profit, the primary use of cover crops is to improve soil for the main crops of corn, wheat, soybeans or other row crops that are planted after the cover crops mature. Cover crops reduce soil erosion from wind and rain. Below the surface, their root systems support soil structure and retain nutrients, particularly nitrogen, phosphorous and potassium.

Cover crops such as ryegrass, winter rye, clover, hairy vetch and alfalfa are planted alongside row crops (corn, soybeans, wheat) at optimum times during the growing season to keep living plants in the fields as long as possible, anchoring the soil and preventing erosion. Legumes and grasses are extensively used, as well as brassicas (such as rape, mustard and forage radish).

Cover crop roots also reduce soil compaction and improve the ability of fields to conserve water after rainfall, thereby reducing the amount of irrigation water required. The organic matter left behind by cover crops contributes to soil organic matter, which improves soil fertility and the yields of other crops grown in the field.

The USDA Natural Resource Conservation Service and private-sector companies such as Monsanto participate in the SHP by providing funding and guidance, and conservation organizations including The Nature Conservancy bring technical assistance. The Midwest Row Crop Collaborative has contributed additional funding so that over the course of 10 years, the SHP will provide a set of specific, data-driven recommendations that farmers across nine Midwestern states can use to improve the productivity and sustainability of their farms.
BECOMING A GOOD STEWARD OF SOIL AND WATER

Jerry wishes to preserve and improve his most important natural asset — his farm soil — and wants to do his part to ensure there is clean water for drinking and recreation. Thus, he has implemented innovative soil management practices based on local climate and soil conditions, reducing the environmental impact of his farming operations.

In the 1980s, Jerry experimented with organic farming, but found that for his farm, tilling the soil to plant seeds and manage weeds resulted in higher erosion and losses of sediment and nutrients into nearby streams, as well as unnecessary wear and tear on his farm machinery.

Jerry receives soil management training from his state agricultural extension office. The training helped him make the transition from tilling his soil before planting crops to a no-till system of weed and soil management that builds the organic matter of his soil. Using biotech corn and soybeans that are genetically modified to be herbicide-tolerant is part of a no-till system, and it enables him to reduce the amount of herbicide he applies to his fields.

Jerry shares his knowledge and experience with new farmers at Soil Health Partnership (SHP) field days and with agriculture and environmental science students from nearby land-grant colleges and universities who visit his farm to conduct research and observe his practices.

To advance stewardship of land and water, Jerry consults with crop and farm advisors who help him assess variations in slope and soil types to understand field hydrology. Based on their analysis, he invested in field tiling (underground pipes that funnel excessive water after rains) for certain parts of the field where rainfall could cause problems with flooding.

He also works with extension agents, a crop advisor and a machinery advisor from a farm machinery dealership to establish a precision farming plan for field preparation, planting and seeding, crop care and harvesting.

Following several years of high prices for crops, Jerry invested his profits into the purchase of a new tractor equipped with auto guidance that helps him accurately pass through fields, avoiding overlap and wasted fuel. He also invested in field...
Precision agriculture is the use of data and technology to increase the productivity and profitability of agricultural operations, including crops, livestock, aquaculture, dairy, forests and orchards.

Farmers use tractors, combines and sprayers with global positioning system (GPS) devices and precision guidance satellite receivers enable them to navigate for sub-inch accuracy in their crop fields. Using integrated software that contains data about their operations, farmers can precisely apply nutrients, control weeds and pests and add water where it is needed for maximum yield.

For livestock operations, sensors on the animals can alert farmers to the presence of a disease before it spreads throughout an entire herd. Farmers are now investing in automated and computer controlled barns that provide consistent temperatures and readily available feed and water.

In forest operations, remote sensing images can measure tree height and canopy information, as well as tree diameter and biomass, as part of a carbon sequestration strategy. Estimating timber volume allows forest managers to make better decisions about where and when to harvest trees.

39% of the U.S. rural population (23 million people) lack access to broadband internet service, compared with 4% of U.S. urban residents.11

Precision agriculture systems continue to spread as the technology improves and is more widely adopted by farmers of all scales around the world, but adoption is limited in many rural areas due to a lack of broadband service. To take advantage of precision systems, farmers need access to farm-wide, high-speed and high-quality fixed broadband and mobile cellular coverage.

Using a software system that integrates field data and climate information, Jerry generates maps that depict the considerable soil variation across his fields. He makes highly accurate and timely decisions about when and where to plant, uses precision prescriptions to apply fertilizer or crop protection products in the right amount and at the right time to avoid product losses after heavy rains, and knows when is the best time to harvest.

More recently, Jerry has increased his income by focusing on producing and selling high-quality livestock feeds. He uses special sensors and a software program developed by John Deere (Constituent Sensing, part of HarvestLab) to measure the sensors that collect data about soil moisture levels and nutrient profiles, enabling him to use precise fertilizer applications only where the soil requires it.
nutrient quality of his corn and alfalfa. Constituent Sensing informs Jerry about the protein, starch and fiber content of his crops, allowing him to make adjustments that result in greater quality and value of his final feed product and thereby reduce spoilage and losses.

Jerry now maintains a growing database of information about his farm, so he can manage and track annual progress towards maximizing the productivity of each part of his land. He has learned which areas of his fields regularly do not produce higher yields and are vulnerable to erosion. He has placed this less productive land into conservation through the USDA Conservation Reserve Program (CRP), establishing a pollinator habitat for bees and wildlife.

A challenge Jerry faces is a lack of access to broadband for approximately 200 acres of his farmland. As a result, he is unable to integrate this land into his farm management system, making it more difficult to track and plan for productivity and environmental improvements.

In addition to practicing no-till farming, planting cover crops and using precision agriculture, Jerry is advancing water quality by adopting nutrient management and edge-of-field practices. With the advice of his agricultural retailer, he practices 4R Nutrient Stewardship (choosing the right nutrient source to apply at the right rate in the right place at the right time) and has also installed a saturated buffer at the edge of his field that runs alongside a stream.

Agricultural producers who reside in targeted watersheds can apply for federal assistance through USDA’s Regional Conservation Partnership Program (RCPP) to install buffers and other water quality innovations like improved drainage water management and constructed wetlands. The RCPP leverages public and private partners for funding and support as farmers make water quality improvements on their farms.

Jerry continues to cultivate healthy soils that sequester carbon while keeping the soil and fertilizer on his farm and away from waterways, boosting the productivity of his crops. He has received recognition from the governor of his state for his exemplary efforts to improve water quality, conservation for wildlife habitat and soil health.

While Jerry has built a strong farm business model during the past 30 years, he continues to rely on the crop insurance safety net to help him during exceptionally bad years of drought or weather disasters that can wipe out much of a crop during a growing season.

The 2014 Farm Bill increased funding for crop insurance subsidies for farmers like Jerry who purchase corn and soybean crop insurance. He would like to see options for expanding insurance coverage to swine production and alfalfa, given that he and his daughter produce these on their farm. With shifting weather patterns and climate change, Jerry wants to be sure that multiple years of drought or more catastrophic events do not destroy the crop and pork production business for Emma.
4R PARTNERS PROMOTE WATER QUALITY

Water availability and quality are critical for human health, recreation and agricultural production. Water quality and agricultural production methods are closely interlinked, and there is an urgent need for farmers and agricultural retailers to adopt best practices that protect water quality and to become advocates to scale up these practices more widely.

To improve crop yields and soil health, farmers apply nitrogen and phosphorus in the form of commercial fertilizer or manure. When these nutrients are not properly applied, or when storms and heavy rainfall occur, nutrients flow off the fields through streams, eventually reaching large bodies of water where they enrich harmful algal blooms or “dead zones” that lack sufficient oxygen to support aquatic life. Such areas in Lake Erie, the Gulf of Mexico and the Chesapeake Bay pose a serious challenge today.

To meet these nutrient management challenges, farmers are increasingly using 4R Nutrient Stewardship practices: choosing the right nutrient source to apply at the right rate in the right place at the right time. Farmers work closely with crop consultants, agronomists and agricultural retailers to develop annual plans for their fields, including how to ensure that crops maximize the uptake of nutrients and how to prevent sediment and nutrient runoff into waterways.

The Western Lake Erie Basin (WLEB) encompasses parts of Ohio, Michigan and Indiana and spans 8.3 million acres. Several major rivers drain into Lake Erie and most of the land in the basin is now used for agriculture, industry and urban development. Only five percent of the basin’s wetlands remain, along with a small forested area.

Since 2012, The Mosaic Company and The Mosaic Company Foundation have played an active role in the development, launch and funding of the 4R Nutrient Stewardship Certification Program in the WLEB. The program is governed and administered through the Nutrient Stewardship Council and the Ohio Agribusiness Association, and includes more than 20 agriculture and environmental organizations.

Today’s agricultural retailers reach more farmers and acreage than ever before, and they provide high quality agronomic services and advice as part of their business model. Recognizing this opportunity, agricultural, environmental and community groups formed the Nutrient Stewardship Council to create the 4R Certification Program for retailers. The certification process includes 44 standards across three categories: 1) training and education in 4R practices; 2) monitoring 4R implementation; and 3) nutrient and application recommendations. Annual audits conducted by third parties help the retailers maintain and verify their practices.

As of July 2017, 44 retailers across the WLEB and the entire state of Ohio have achieved certification in the 4R Nutrient Stewardship Program. Together they are reaching 5,900 farmers and 2.76 million acres with science-based, proven practices that keep fertilizer in the crops and soils rather than in Lake Erie.

After just 2 years, the 4R Program impacted 35% of the farmland in the WLEB, with the potential to soon reach nearly all farmland in the watershed.12

Ongoing evaluation of the program’s progress is made possible by a five-year grant from the 4R Research Fund, sponsored by companies in the fertilizer industry including The Mosaic Company. Efforts continue to expand the program and reach more farmers each year.
4R Advocates Expand Their Reach

Since 2012, the Fertilizer Institute has recognized 30 farmers and 30 agricultural retailers as 4R Advocates. These 60 professionals represent 144,425 acres of cropland across 17 states. They share the benefits of proper nutrient stewardship with other growers and partner with conservation and environmental groups to ensure a wider understanding of the importance of soil and plant health.

Among the practices they advocate for are the following: incorporate fertilizer into the ground rather than broadcasting it; delay application for fields that are prone to flooding; avoid applications before heavy rains or when soils are frozen; and avoid applying fertilizers near ditches, streams or waterways.

DIVERSIFYING FOR RESILIENT GROWTH

Given the challenges that many farmers in the U.S. have faced with boom and bust agricultural economies, and listening to her father’s advice about the importance of being ready for an uncertain future, Emma has decided to continue the path of diversification on her father’s farm.

Emma studied livestock and farm management at her nearby land-grant university and is now focused on building the family pork production capacity — but with an eye to specialization and consumer engagement.

Noting the growing consumption of various specialty pork dishes by her friends and learning about the growth in pork demand from Mexico and throughout many countries in Asia, she has decided to develop and expand the farm’s production capacity by providing high quality pork for domestic and export markets.

Emma benefits from decades of public research and development that has translated today into high pork productivity in the United States.

Today it only takes 5 breeding hogs to produce the same amount of pork from 8 hogs in 1959, or 38% fewer breeding animals.13

Her business would benefit from new trade agreements with countries in Asia that enable her to compete for those growing markets against producers from the European Union (EU).

Caring for pigs, especially during farrowing (when pregnant sows give birth) and during the critical period for piglets after birth, requires workers who can be available around the clock. Along with many ranchers, dairy farmers and horticulture producers, Emma faces a critical shortage of labor to ensure year-round productive operations and well-cared for animals.

In the U.S., farming, fishing and forestry account for 20% of all immigrant workers.14

Emma and other farmers are waiting for policy solutions such as immigration reform to help meet her need for year-round labor. In the meantime, with her father’s support Emma acquired a loan to invest in a new state-of-the-art barn, allowing her to put in place some of the highest pork industry standards for animal care, environmental management and to maximize productivity.
Emma is an independent contract grower in a multi-year agreement with Smithfield Foods. While Smithfield assumes the market risks and owns the hogs, Emma raises and cares for them. Under the agreement, she is protected from market fluctuations and receives a predictable income stream.

Emma also agrees to abide by Smithfield's Animal Care Management System, with verification of compliance. The system includes requirements for: shelter that meets the animals’ needs; access to adequate water and high-quality nutritional feed; humane treatment of animals that complies with all applicable laws and regulations; identification and appropriate treatment of animals in need of healthcare; and use of humane methods to euthanize sick or injured animals not responding to care and treatment.

Smithfield encourages contract growers to install group housing systems for pregnant sows. Once confirmed pregnant, the sows are housed in groups until they are ready to give birth.

**SUSTAINABLE SHARED VALUES**

Emma wants consumers to understand how she manages her farm and how she puts into practice her values of sustainable production and animal well-being.

She creates short videos for her website and hosts a live weekly web chat from her farm. She also interacts with consumers at farmer’s markets and explains how she cares for her pigs and implements sustainable production methods.

In addition to demonstrating many aspects of pork production and animal care with her social media feed, Emma also discusses how the carbon “ hoofprint” of pork production is being lowered on her farm.

**PRODUCTIVITY FEEDS RISING GLOBAL PORK DEMAND**

As recently as 1989, the U.S. was a net importer of pork; today it is a net pork product exporter, reaching more than 100 countries. The U.S. exported nearly 26 percent of its domestic pork production in 2016, with most of the demand coming from Mexico, Japan, Canada, China and South Korea. Consumers in these markets trust the safety and quality of U.S. pork products and demand continues to grow.

The Trans-Pacific Partnership (TPP) trade agreement would have reduced tariffs on U.S. exports of pork to Asia and Pacific markets. Without the TPP agreement, U.S. pork producers will lose $387 million in sales per year, primarily due to tariff reductions that would have taken place in the Japanese market. Competitors such as the EU are filling the demand gap by negotiating new agreements with many of these countries.

Producers in the U.S. also face uncertainty over future exports to Canada and Mexico as the North American Free Trade Agreement (NAFTA) is renegotiated. In 2016, the U.S. shipped $2 billion in pork products to Mexico and Canada, and if tariff levels increase due to a renegotiated treaty, pork producers will lose critical revenue.

Ensuring that trade is open, fair and based on common scientific standards with low tariffs will enable U.S. farmers to sustainably meet the growing demand for pork and other livestock products among the expanding consumer classes in Asia and Mexico.

**Figure 8: Country Shares of U.S. Pork Exports, 2016**

SMART BARNOS FOR HEALTHY PIGS

Many pork farmers are now investing in automated computer-controlled barns for their animals, providing consistent temperatures and readily available feed and water.

Waste falls through slatted floors where it is moved to storage tanks or anaerobic lagoons until it is ready to be land applied as fertilizer, in accordance with environmental permits. Containment of manure in this manner reduces loss to the environment and provides a valuable source of fertilizer or energy. Use of precision data in the smart barns allows farmers to increase productivity by reducing energy use and saving labor while protecting pigs from predators and disease. Feed for the pigs is formulated to maximize nutrition and optimize growth and reduce levels of nitrogen in pork manure, thereby reducing environmental impact and cost for the farmer.

Pigs are housed with temperature control and monitors for early detection of disease or lameness so problems can be addressed before impacting the entire herd. Fans, misters and heaters are part of the climate control systems in these smart barns. Some of the new technologies include personal ear tags that allow workers to check them for health and expected farrowing date.

Many pork production companies are shifting to new systems of housing for pigs, especially for pregnant sows. Companies such as Smithfield require their U.S. company-owned farms to convert their housing from individual gestation stalls to group housing systems for pregnant sows by the end of 2017. In addition, Smithfield recommends that its contract sow growers transition to group housing by 2022. The company is providing guidance and expertise to help contract growers reach this target.

Each group housing design has unique advantages and disadvantages for the well-being of the sow. For example, it may allow free roaming of the pigs, trickle watering and electronic feeding stations, and deep bedded areas. Improving both the animal husbandry skills of the caretaker and science-based housing will support the productivity and comfort of the animals.

Emma works to produce healthier herds that make better use of all resources, such as feed and water, while reducing waste and loss. Her approach to comprehensive improvements in herd management includes data collection to understand variations in her herd, provision of nutritious and sustainable feed and controlling disease while making sure all pigs reach an optimum weight for market.

Improving the efficiency and nutrition of animal feed brings environmental benefits and cost reductions to pig farmers. The highly productive alfalfa, biotech corn and soybean crops produced on Jerry and Emma’s farm provides an excellent feed base for livestock. Emma works with veterinarians and her father to formulate highly nutritious feeds that include enzymes to enhance nutrient uptake, and she uses health products that prevent disease, especially in newly-weaned piglets.

Between 1959–2009, pork feed efficiency improved by 33% and crop yield increases led to a 78% decrease in land required per 1,000 pounds of pork produced.18

Pork production in the U.S. today has a small carbon footprint, with just 1/3rd of 1% of total U.S. greenhouse gas (GHG) emissions.17

Smithfield Foods is on track to fulfill its commitment to transition all pregnant sows on company-owned farms to group housing systems by the end of 2017. Photo credit: Smithfield Foods
KEEPING PIGS HEALTHY

Pork producers focus on keeping their pigs healthy during their entire life-cycle. Receiving good training in animal husbandry, regularly monitoring their herds and scheduling visits from veterinarians are all practices that ensure pigs stay healthy and that disease can be detected early.

A particularly vulnerable time for piglets happens during the nursery phase after weaning. Pathogenic *E. coli* is prevalent in livestock herds and causes post-weaning diarrhea lasting up to 14 weeks of age, threatening the health and lives of piglets. Elanco Animal Health Company has conducted extensive research and developed an animal-use-only antibiotic (Kavault™) that veterinarians can prescribe as a feed additive that is proven to reduce the incidence and overall severity of diarrhea from *E. coli* in groups of weaned pigs.

Another disease of great concern to the entire livestock sector is the deadly foot-and-mouth disease (FMD), a highly infectious virus that affects cattle, pigs and sheep. While no outbreaks have occurred recently in the United States, it is endemic in many parts of the world. An outbreak in the U.S. would result in the closure of export markets, resulting in a wide economic ripple effect across the entire agricultural industry. Surplus pork, beef and sheep in the domestic market would reduce demand also for corn and soybean feeds, with estimated losses of $128 billion for livestock, $69 billion for corn and soybeans, and 1.5 million jobs lost during the recovery decade.¹⁹

To mitigate an outbreak of FMD and maintain food security in the U.S., an adequate vaccine bank must be maintained. Sufficient supply of FMD vaccine must be available for early, robust action to vaccinate herds of animals near an outbreak to prevent the national spread of the disease.
Policy Priorities for Improving Productivity and Sustainability in United States

Farmers in the United States face new challenges from changing consumer preferences, low commodity prices, volatile weather conditions and uncertain global trade patterns.

The upcoming reauthorization of the U.S. Farm Bill and the potential for new investments in research and infrastructures for transportation and communications are opportunities to further strengthen U.S. global leadership in productive, innovative and sustainable agriculture, while boosting farm productivity and helping meet the Sustainable Development Goals.

Policies that advance trade agreements will also play a role in supporting farmer and rural livelihoods and keep prices of food and agriculture products affordable for consumers.

Invest in Public R&D and Extension

R&D funding levels authorized in the current farm bill account for less than one percent of all farm bill spending. These funds support the U.S. Department of Agriculture’s capacity to conduct research and development for sustainable production technologies, the economics of farming and agriculture systems and food safety and quality. They also provide the land-grant colleges and universities with human talent and research and extension support.

Experts say the USDA’s annual research budget should be substantially increased from today’s levels to reinvigorate the productivity growth rates of American agriculture and ensure future sustainability of the sector. Current funding levels are inadequate to meet the need. R&D investments have a long gestation period and require sufficient and steady investments now to bear fruit in coming decades while reducing costs in future years for farmers and the food and agriculture industries.

The 2014 Farm Bill took a step toward this goal with the establishment of the Foundation for Food and Agricultural Research (FFAR), a nonprofit corporation that supplements USDA’s research investments by mobilizing matching private-sector funds. Public resources for FFAR leverage additional funding annually in public-private partnerships for cutting-edge research.

Additional funding for animal science research is urgently needed. Outbreaks of livestock diseases such as avian influenza and foot-and-mouth disease could devastate the industry, yet public research funding has been stagnant in real dollars for the past two decades. The next Farm Bill provides the opportunity to address the need for increased funding for animal science research and for a vaccine bank for high-consequence animal diseases.

Embrace Science-Based and Information Technologies

Precision agriculture systems and crop and livestock biotechnologies have demonstrated their value in improving productivity and sustainability for farmers of all scales. New plant and livestock breeding technologies have the potential to deliver additional value and further enhance the sustainability of agriculture. Maximizing public and private agricultural R&D investments to bring more productivity and sustainability to farmers requires regulatory systems that work efficiently and regulators that are up to speed on the latest scientific advancements.

The regulatory system for biotechnology, which has not been revised since 1986, must be streamlined and modernized. Plants and animals derived from biotechnology and new breeding technologies should be assessed for potential health or safety impacts, rather than from the processes used to produce the trait or product. Without streamlined modern regulatory systems, innovation from small companies and universities may not reach farmers who need solutions from many different sources.
Enhance Private-Sector Involvement in Infrastructure and Agricultural Development

An efficient, well-maintained transportation infrastructure enables U.S. farmers to supply markets around the world, while keeping costs low for consumers. Yet the American Society of Civil Engineers estimates there will be a $5.18 trillion shortfall (in constant 2015 dollars) between now and 2040 in funding required to improve and maintain the nation’s roads, railways, water and electricity infrastructures, airports, inland waterways and marine ports.23

Inland waterways and ports are the agricultural highways of America’s Midwest. In 2015, 72 percent of U.S. agricultural export volume, valued at $128 billion, was transported to ports via waterborne commerce. The Inland Waterways Trust Fund and the Water Resources Reform and Development Act of 2014 provide significant federal resources for maintenance of waterways and ports, but still leave a $43 billion funding gap by 2040, which will result in delays, higher costs of products and inefficiencies.24

Current proposals for a new federal infrastructure initiative rely on significant funding from local, state and private-sector sources as well as from user fees. **These resources must be accompanied by a robust increase in federal funds for this essential public good, particularly in rural areas that are less likely to attract private-sector investments.**

Public-private partnerships are needed to extend broadband services to rural areas so that farmers have access to high-quality, high-speed fixed broadband and mobile cellular coverage for precision agriculture. Federal policies should incentivize the expansion of broadband infrastructure and services out to the croplands and ranchlands where farmers are deploying new, innovative equipment and data technologies. Policies should also protect existing spectrum uses by agriculture, ensure more spectrum is made available for commercial use, and reduce the red tape associated with building rural broadband networks.

The U.S. government, the insurance industry and farmers have collaborated to build an effective insurance safety net, which offers a variety of insurance products protecting farmers against price volatility, crop failures, pests and catastrophic events. In doing so, the need for costly, unpredictable disaster relief legislation has been all but eliminated. **The next Farm Bill should preserve this successful risk management tool and continue to offer a variety of insurance options to farmers at an affordable price.**

Expand Regional and Global Agricultural Trade

Trade agreements such as the **North American Free Trade Agreement (NAFTA)** benefit U.S. agricultural producers and their communities. Canadian and Mexican tariffs on U.S. farm products have been eliminated, and with the duty-free access and integration of trade standards, Mexico and Canada have become top purchasers of U.S. agricultural products. Annual U.S. agricultural exports to Mexico have risen by $13 billion since NAFTA was ratified.25 It will be vital for U.S. farmers to retain a fair and well-functioning NAFTA trade agreement while seeking further trade facilitation improvements during its renegotiation.

After withdrawal from the Trans-Pacific Partnership Agreement (TPP), the U.S. is expected to lose agricultural market share across the Asia and Pacific region to competitors such as the European Union, making it even more important that NAFTA’s tariff eliminations remain in place as it is renegotiated. **The U.S. also needs new trade agreements that enhance market access and lower tariffs on U.S. agriculture products** with countries like Japan and Vietnam.

**Cultivate Partnerships for Sustainable Agriculture and Improved Nutrition**

In response to the global food price crisis of 2007/2008, the U.S. dedicated significant new resources ($4.2 billion) toward a total global multilateral goal of $22 billion to boost agricultural development and food security in developing countries. Congress passed the **Global Food Security Act** in 2016 authorizing the **Feed the Future Initiative (FTF)**, which invests in agricultural productivity, food security and nutrition in select partner countries. FTF leverages resources from the private sector and from local and national governments to make the investments more sustainable. In 2015, FTF boosted the income of nine million producers by more than $800 million and reached 18 million children under the age of five with nutrition interventions.

To respond to the rising needs during the Great Recession, the U.S. increased funding for domestic nutrition programs, including **SNAP** (Supplemental Nutrition Assistance Program), WIC (the Special Supplemental Nutrition Program from Women, Infants and Children), the **National School Lunch and Breakfast programs and TEFAP** (The Emergency Food Assistance Program). These programs reduce food insecurity and improve nutrition for vulnerable consumers while benefitting farmers and food retailers. Innovative programs such as the **Food Insecurity Nutrition Incentives (FINI) Program** help low-income people purchase fresh fruits and vegetables at farmers markets.

Maintaining and leveraging these investments in global and domestic programs will support the achievement of the Sustainable Development Goals to eliminate extreme poverty and hunger.