Advancing Resilient Agriculture:

Recommendations to Address Climate Change

American Society of Agronomy | Crop Science Society of America | Soil Science Society of America

Climate Change Solutions

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Photo: Kirsten Strough, USDA

Build on a legacy of excellence:
Agriculture can pay back the loans it has taken from the planet

Historically, agriculture used plentiful natural resources, including land, water, soil, and sunlight, to their fullest extent with the goal of increasing agricultural productivity and food security. By those metrics, modern agriculture has been breathtakingly successful, even considering the mounting challenges associated with anthropogenic climate change. However, it has done so without adequate regard for its environmental effects, many of which contribute to the excess greenhouse gases that cause climate change and threaten the advances agriculture has achieved. The goals of agriculture in the 21st century have shifted. Today's agriculture needs to balance emissions with sequestration, water use with water retention, and soil building, not soil erosion, all without increasing acreage in production; it needs to efficiently pay back what it withdraws from the planet and stem the emissions that cause climate change.

As the world's population continues to grow, agriculture is called upon to produce even more, but what seemed like a limitless supply of soil and fresh water only a few generations ago is becoming increasingly scarce. Earth's ability to handle wanton greenhouse gas emissions without egregious repercussions has met its limit. Continuing to put human needs at the expense of all else has resulted in negative externalities that threaten our ability to feed people while preserving the places we love.

Specialization and intensification have significantly increased U.S. agricultural productivity in the last 100 years, but these strategies have also left little room for variability or error. Agricultural production is threatened by the weather variabilities caused by climate change, which produce conditions that exceed the tolerances of crops and food animals; increase favorable conditions for weeds, pests, and diseases; and increase weather and growing season variability. This will only become more extreme as greenhouse gas emissions continue to accumulate in the atmosphere, and agriculture itself contributes 10% of U.S. greenhouse gas emissions. To shed its dual role as both villain and victim, agriculture must become part of the solution to climate change. By embracing an integrated, systems approach that considers the delicate balance of relationships between the organisms that comprise agricultural ecosystems, farmers can become climate heroes.

The first step toward achieving ecosystem balance is to decrease agriculture's overall footprint. Making changes that reduce greenhouse gas emissions now will make it easier to offset, through sequestration, for example, emissions that cannot yet be avoided. The science is clear on which reductions will be necessary, and how they can be achieved, but there is no single practice, no magic bullet. What is needed are collections of context-specific practices tailored for each region, climate, soil type, and farming system.

Strategies for water and nutrient management, reducing emissions, sequestering carbon, preventing erosion, reducing stress on plants and animals, protecting germplasm and crop wild relatives, and reducing or repurposing waste must be weighed against their costs and agronomic impact. Every farm is unique, every situation complex. However, with multifaceted communication and outreach, including standardized data collection, trusted technical assistance, and networks of demonstration sites and information sharing, this complexity presents opportunities to maximize a farm's unique potential to reduce agriculture's collective footprint.

This statement was developed by a Task Force of Society members and CCAs, with input and review from the ASA, CSSA, and SSSA Science Policy Committees and the assistance of the Science Policy Office staff. It was approved by the ASA Board of Directors, the CSSA Board of Directors, and the SSSA Board of Directors on July 30, 2021.

Data drives decisions:

Climate-smart agriculture needs data infrastructure

Farmers and ranchers do more than provide food, feed, fuel, and fiber. They are also the last great stewards of the nation's soil, water, and nutrient cycles. Healthy agricultural ecosystems also filter air and water, sequester atmospheric carbon, and promote biodiversity, a collection of benefits also known as ecosystem services. While all ecosystems, natural and managed, have the potential to deliver these essential benefits, agricultural systems are particularly important because there is control over which benefits are delivered and how; a producer or landowner can leverage this control through ecosystem services markets and climate-smart agricultural incentive programs.

While the concept of ecosystem services is straightforward, the complexity of the systems and the scientific and research capacities needed to measure them are anything but. The "wicked problem" of ecosystem services is that each practice and each benefit does not operate in isolation—their ultimate potential and impact lies in how they synergize, counteract, or are modified in concert. Elucidating this complex dance is a research frontier that scientists have only begun to understand, but it is essential for the success and credibility of climate-smart agriculture programs. To achieve this understanding will require the research community to build on its solid foundation with more integrated, systems-based approaches to implementation and monitoring and to account for variations in potential for a given practice from place to place and across farming systems.

What is needed are investments in technology, national coordination and communication, harmonization of data, and long-term, cross-disciplinary research support. These investments could be coordinated through an integrated, national ecosystem services monitoring network, which would help scientists gain a predictive understanding of how agricultural ecosystems function. The science could feed back into decision-support tools to help producers and landowners choose which practices have the most significant effect and where, while providing benchmarks for ecosystem services credit buyers and building confidence that their investments are producing measurable results.

The information from an ecosystem services monitoring network would be akin to a meteorological forecast, which, similarly, integrates constant streams of data from a nationwide network of local weather stations. These weather stations all contribute the same information in the same format to a centralized location, and the data is then made freely available. Today, the country has reliable weather forecasts because the National Weather Service collects, maintains, and supplies this information. Agricultural data has no similar mechanism for standardized collection, maintenance, and use. Although efforts are underway to establish measurement, reporting, and verification for ecosystem services, nationwide data from many kinds of operations is vital to ensure equitable participation from all kinds of farms.

Many weather station-type programs collecting ecosystem data are already in place. USDA boasts a successful Long-Term Agroecosystem Research (LTAR) network, a partnership among 18 research sites currently focused on the sustainable intensification of agricultural production. Other opportunities for data collection include USDA's Climate Hubs, a collection of ten regional centers that link USDA research to practitioners, state experiment stations, and individual producers who may collect their ecosystem services data to participate in markets or other programs. USDA has also released a solicitation for proposals to monitor soil carbon sequestration on lands enrolled in the Conservation Reserve Program. What is missing is the funding to collect, coordinate, network, and harmonize data from these disparate sources. Most funding for ecosystems research and data collection comes from USDA's Agriculture and Food Research Institute (AFRI), but AFRI grants do not support long-term research nor are its grants large enough to cover the range of projects needed to ensure equitable participation in climate-smart programs and ecosystem services marketplaces. With such funding, data collectors could communicate with each other, with technical assistance hubs, and with on-the-ground-farmer networks to improve and refine data collection and add value to all who participate.

Soil Erosion

Millennial geologic processes have created the soil that humans depend on to produce 95% of our food. Throughout history, agricultural practices from deforestation to tillage have contributed to the erosion of soil and the fall of civilizations in just a few thousand years. Even now, the United States is eroding soil between ten and one hundred times faster than it is generated. Barren regions of farmland are already visible via drone and satellite imagery, and the nation's ability to grow crops will likely be affected within this century. However, nationwide adoption of known soil management practices would effectively end erosion. Policies that encourage no-till, cover crops, intercropping, wind breaks, water management, and intensive rotation grazing are needed now.

Photo: Soil erosion in a wheat field. Jack Dykinga, USDA.

Ecosystem Services Incentivization

The Environmental Quality Incentives Program (EQIP), the conservation stewardship program (CSP), and ecosystem services markets are efficient ways to pay producers or landowners directly for the ecosystem services—the deliverables—that their climate-smart practices provide. EQIP and CSP are government programs funded by USDA. Ecosystem services markets are largely private, with payments coming from organizations that wish to promote climate-smart practices in their supply chains and/or purchase credits to offset their emissions.

Photo: Leonardo Aguila utilizes the EQIP to install a new irrigation system. Lance Cheung, USDA.

Photo right: Sensors are used in an irrigation management system. Lance Chueng, USDA.

Inset: A smart device used to review data. Lance Chueng, USDA.

USDA's Agriculture Research Service (ARS) is currently investing in data infrastructure capable of housing publications and datasets from its own researchers and, eventually, its extramurally funded researchers as well. This effort must be greatly expanded into a universal agriculture data repository. It would include data produced by ecosystem services monitoring, historic datasets (e.g., from conservation districts and the National Cooperative Soil Survey), and from academic agricultural research not funded by USDA. The repository should ascribe to FAIR (findable, accessible, interoperable, reusable) principles. Funding designated to set up the repository must also include a distribution strategy and tools for the training and incentivization of researchers and students to contribute organized and annotated data and metadata. USDA should hire specialists to create data extraction and upload wizards for automatic extraction, standardized formatting, and depositing of data directly from research equipment, and these data specialists should work with equipment designers. USDA should also put considerable thought into what data should be collected, data management, long-term sustainability, preservation and curation practices, and importantly, data privacy, especially where working farms are concerned. New USDA programs that incentivize climate-smart agricultural practices should include a mandatory data collection component that feeds information into this data repository.

The data repository's success will be measured in its usefulness. Most data repositories currently available for agriculture data exist primarily as external hard drives—places to park data that are as useless as a laboratory notebook written in a foreign language. Great care must be taken for USDA's repository to avoid that fate. For it to achieve its potential, it needs to be amenable to independent researchers developing web tools for searches, analytics, and predictive modeling, for example, through consistent file formats and an open access structure. The data itself is invaluable, but the FAIR, open access structure is what will drive scientific advancement even beyond climate-smart agricultural practices.

Context is crucial:

Research underpins mitigation and improved resilience

Monitoring networks are vital to tracking current conditions and evaluating the effectiveness of known practices, but the tools and technologies currently available are insufficient to stop climate change or to protect every farm from the inevitable and increasingly more severe natural disasters that the climate's destabilization is triggering. USDA should invest significantly in research that mitigates climate change and improves overall agricultural and food system resilience.

Regenerative agriculture, which includes carbon sequestration as a central tenant, encompasses important strategies for sequestering carbon and increasing resilience. Such strategies include reducing disturbance, keeping the ground covered, increasing biodiversity, and tightening nutrient cycles, among others. USDA needs to incentivize these practices across the country, but because their effectiveness will vary across regions and farming systems, new strategies, tools, and technologies must also be developed for a nation-wide implementation to be successful. USDA should invest in a soil carbon moonshot—research programs that investigate ways to significantly scale the amount of carbon sequestered in the soil through soil health strategies, new crop and animal varieties, forestry, and the diversification of cropping and farming systems.

USDA supports crop breeding programs that aim to provide farmers with new crop varieties and, in some cases, new species capable of sequestering more carbon, withstanding drought or other extreme climate events such as heat stress, or thriving in cropping systems with carbon-sequestering varieties. These breeding programs are also important as pest and pathogen ranges change, new diseases appear, and as shifts in growing seasons and hardiness zones leaves growers unable to plant crops they have planted for decades. This is already the case for coffee and citrus, which are each facing climatic threats. In some cases, farmers need entirely new crop options, and breeders are called upon to adapt crops to new geographies and cropping systems. Moreover, as production increases in urban areas and vertical farms, varieties that can thrive in these new conditions are essential.

Conventional breeding programs are essential for this effort, and USDA should increase its support for breeding programs in every state. For certain crops, such as those with long generation times, like trees, and for certain traits, such as improved photosynthetic efficiency, conventional crop breeding is less effective. Plant breeding innovations, like gene editing, are the best way to address these challenges and provide huge cost and time savings. To address the pressing needs of agricultural production rapidly and efficiently, they should be included in USDA's effort to mitigate climate change and improve resilience.

Funding for USDA's research agencies to support these and other efforts to address climate change is essential. These agencies, such as the National Institute for Food and Agriculture (NIFA) and ARS, support low-risk, high-reward research. While this strategy is safe, it can, in some cases, hinder transformative innovations. The Agriculture Advanced Research and Development Authority (AgARDA) is a pilot effort for a new, Advanced Research Projects-style research agency (ARPA) in the USDA authorized by the 2018 Agriculture Improvement Act (Farm Bill) to focus solely on agriculture. USDA should set up AgARDA as an independent, high-risk/high-reward, ARPA-style agency to enable the research necessary for engendering transformative impacts on climate change mitigation and resilience through our natural and working lands.

> "USDA should invest significantly in research that mitigates climate change and improves overall agricultural and food system resilience."

Greenhouse Gas Emissions and Carbon Sequestration

Considerable efforts can, and should, be made to reduce emissions, such as the reduced use of fossil fuels, improved energy efficiency in animal confinement, improved refrigeration and transport, and reduced packaging. It should be noted that many soil health strategies have the beneficial effect of reducing emissions and sequestering carbon, such as the use of cover crops and planting and protecting trees and other perennial plants. For example, no-till can reduce machinery passes on fields. There are also strategies for managing methane emissions from manure, and many nitrogen application techniques reduce nitrous oxide release, such as subsurface drip irrigation methods, nitrogen stabilizers and inhibitors, the use of slow-release fertilizers, and banding and splitting nitrogen applications over the course of a season. The amount and timing of nutrient application should be closely tied to precipitation frequency, duration, amount, and intensity. Producers often apply too much (up to 50% inefficiency) because it is less risky to the bottom line. The science to reduce this risk is known, but there are few incentives for producers to take advantage of these advances.

Photo: Perennial pastures. Preston Keres, USDA.

Water Strategies

Strategies for water management include the use of soil moisture probes in irrigation systems and recycled water in animal production. No-till and cover crops improve soil structure and moisture infiltration, leading to fewer irrigation needs. Water conservation can also include waterways and terraces that manage waterflow, filter strips, vegetated riparian buffers, and two-stage ditches that reduce erosion and sediment filling reservoirs. Practices that irreparably diminish capacity should be avoided unequivocally, such as when overdrawing water from aquifers causes their capacity to shrink.

Photo: Drip irrigation tubes.
Lance Cheung, USDA.

Photo right: Urban farm utilizes solar energy, composting, and aquaponic systems.
Preston Keres, USDA.

There is no vaccine for the environment:

Resilience is needed throughout the food system

The United States faces near-constant natural and man-made disasters and disruptions. In 2019, 40% of South Dakota farmland and hundreds of thousands of acres in the Midwest were not planted because of extreme rainfall and flooding. In 2020, California experienced another record-breaking wildfire season, a devastating derecho struck Iowa and other Midwestern states, and the Southeast experienced a hurricane season with a record-breaking 30 named storms while still recovering from three Category 3 or higher storms from the year before. Yet even in the face of these extreme disruptions, the nation's agriculture and food system must continue to support rural communities, provide the agricultural base of our national economy (food, feed, fuel, and fiber), and deliver climate change-fighting ecosystem services like carbon sequestration. Agriculture researchers are working on the agronomic strategies needed to help producers weather these damaging events.

Agronomic researchers regularly look at resilience through the lens of soil health and cropping systems. For example, they ask the following: Is the soil in a position to absorb water in case of flood or retain it in case of drought? Will it resist erosion? Is the farmer prepared to plant a new crop that could succeed in the aftermath of a flood or derecho? Are the farm's crops able to withstand extreme pest pressures or saltwater from a storm surge or a rising coastline? Researchers acknowledge that a producer's primary concern with respect to natural disasters is maintaining financial viability through agricultural production. Conservation concerns like soil health may rank secondary.

Fortunately, there are many scientifically backed strategies that deliver resilience in the form of agricultural productivity while also providing ecosystem services and promoting conservation. Soil carbon sequestration, for example, reduces atmospheric greenhouse gases, mitigating the effects of climate change, while the practices that achieve sequestration, such as the use of cover crops, improve the soil's water-holding capacity, increase water filtration, and provide habitat for declining populations of pollinators. However, producers need to know which strategies will be the most impactful in their unique situations, and scientific certainty is lacking on precisely how well many of these strategies work in different regions and production systems amidst a changing climate. Research and multilevel communication are necessary to demonstrate how and where different strategies are effective.

The accumulation and distribution of relevant information for agronomic strategies, tools, and technologies are important but will not be enough to achieve on-farm resilience. 2020 saw the rise of a global viral pandemic. Covid-19 is a zoonotic disease that disproportionately impacts less healthy populations, especially those affected by obesity and diabetes—conditions that are directly related to food, among other factors. The pandemic laid bare a fragile food system that specializes in cheap delivery of calories at the expense of a healthy population, and that prioritizes efficiencies and economies of scale over environmental concerns. Resilience is needed across the board, from farm to fork and seed to supermarket. More than agronomic strategies are needed to reduce volatility and extreme variations in the food supply and to safeguard the health of people and the planet.

In 2020, amid supply disruptions and empty grocery shelves caused by the pandemic, consumers would have benefited from a food system with more local options. Traditional agronomic research tends to focus on operational resilience in the face of wildfires, hurricanes, droughts, new pests and pathogens, and other climate-related disruptions, but a broader perspective is needed. A food grid that connects local suppliers to demand and that enables circular systems that reuse or repurpose materials is one way to build resilience in the supply chain. Such a system would certainly benefit consumers but would also have far-reaching effects on producers, many of whom were stuck with products they could not send to market. The term "waste" would not be appropriate for those products, which were only wasted because they could not find the right market at the right time. Just so with other kinds of agricultural products or by-products—waste is a process, not a product, and a food grid would move such products to where they are needed, reducing wasted resources.

Researchers must ask how well a farm is placed to cope with any kind of disruption and how it could deliver nutritious food for local need, especially amid disruptions. Producers would have benefited from improved logistics and resilient markets so that they could pivot to new distribution channels for their products when major buyers dropped off the map. And food banks could have benefited from more concerted efforts to divert excesses to those in need, reducing the amount of food left in the fields and increasing food access and availability to vulnerable populations.

Developing food and agricultural systems that are resilient to stressors depends on risk models with the goal of keeping a producer economically viable while ensuring a secure and safe food supply. This requires looking beyond an agronomic researcher's typical area of expertise. For example, producers growing leafy greens in the Salinas Valley are at high risk of *E. coli* contamination. If the pathogen is coming from nearby animal operations, these growers may find it nearly impossible to mitigate their risk using traditional agronomic practices alone. What is needed is an interdisciplinary perspective and open lines of communication to facilitate cooperation among multiple kinds of agricultural operations and stakeholders at a regional and national level.

> "Producers need to know which strategies will be the most impactful in their unique situations, and scientific certainty is lacking on precisely how well many of these strategies work in different regions and production systems amidst a changing climate."

Agricultural Wastes

Large reductions in waste could be achieved by diverting agricultural, forest, food, or green waste towards beneficial applications such as fertilizers, compost, biochar, and bioenergy. Oftentimes, the closing of loops is hampered by a lack of communication between those with waste streams and those in need of nutrient streams, but there are also situations in which the production and use of materials are distant, and feasibility of distribution must be assessed. Logistics and transportation are challenges, but a well-planned communication system using sensors, tests, and user-input could pinpoint what is available and what is needed in real-time. Like an energy grid that connects energy production with need, a national food grid would decentralize and reduce risks associated with the flow of agricultural goods and waste.

Photo: Food waste used for compost in a community garden.
Lance Cheung, USDA.

Certified Crop Advisers

Certified Crop Advisers (CCAs) play a pivotal role in conservation practice and technology adoption throughout the North American agriculture landscape. Due to their extensive agronomic training and in-field experience, they are deeply trusted by their farmer clients and routinely consulted for critical on-farm decisions. Most CCAs are employed by either a farm input supplier or an agriculture retail or sales operation, though many are self-employed, independent consultants. Nearly 25 percent of CCAs serve more than 70 growers and more than 50 percent of CCAs serve more than 25. More than 50 percent of CCAs service more than 20,000 acres of land for their clients. With more than 13,500 CCAs scattered across North America, their reach and impact are extensive.

Photo: Betsy Bower, CCA gets ready to take a spring biomass sample.
Betsy Bower, CCA-IN.

Photo right: Dr. Ray Ward, CCA and Dr. Nick Ward of Ward Laboratories analyze soil in a soybean field in Nebraska.
Hannah Dorn, CCA-NE

Connect the dots:

Communication and outreach are key

Throughout the nation, agricultural producers are working to improve the economic and environmental sustainability of their operations. Many farmers are eager to share how they doubled their soil carbon over their lifetimes, or how they have now permanently parked their plows. These accomplishments were made possible in part through unbiased information coming from research institutions and federal research agencies. However, if only published in scientific journals, even the most important advances will have little practical impact because these methods of information sharing are not accessible. Collaborations among universities, federal agencies, producers, and trusted advisers have enabled the access that is needed and produced profound improvements in the nation's soil and environmental health.

Agricultural extension and USDA's Natural Resource Conservation Service (NRCS) employees work along with certified professional advisers, such as Certified Crop Advisers (CCAs), to bring the latest techniques and technologies to producers. NRCS employees are extremely knowledgeable and help communicate essential information from the scientific community, but there are too few "boots on the ground" to offer personalized advice to producers for their operations' unique needs. CCAs are trusted partners who work closely with producers to offer advice specifically tailored to each operation.

Some CCAs are also extension specialists and have extensive scientific or local policy knowledge that informs their recommendations. Others primarily rely on continuing education, conferences, and other lines of communication with the scientific community. Open communication between agricultural research scientists and those providing on-the-ground advice is essential. Yearly national and regional conferences are helpful, but the focus needs to shift so that information flows in two directions. Currently, an emphasis is placed on translating science to practice, but research scientists also need to hear from technical assistance providers who can tell them what producers need so as to better inform their research questions with real-world challenges.

The educational content of conferences needs to synthesize scientific advances with regional, national, and even global efforts. For example, if producers are interested in selling credits through ecosystem services marketplaces, CCAs need to know what metrics are used to evaluate credits, how to measure ecosystem services, and the science that underpins the marketplace. This knowledge is essential for advisers to help a producer weigh the benefits of participation.

Strength lies in diversity:

Elevate all voices to confront climate change's vast repercussions

It is important to have a diversity of voices at all levels, from the scientists choosing which research projects to pursue to the technical advisers who can reach underrepresented farmers. Barriers of all kinds prevent people of color from pursuing careers in science and agriculture, and this needs to change. Climate change is an existential threat, and the world needs every available mind to reach its potential. What is needed are inclusive research institutions, accessible conferences, a deep assessment of the challenges faced by researchers of color, and discipline-wide plans to address them.

Frequent conferences where researchers and technical advisers share challenges, opportunities, information, and experience are fundamental to the development and dissemination of conservation techniques. Equally fundamental is making sure underrepresented technical advisers and producers can participate and access the tools, techniques, information, and technologies that agricultural researchers provide. This can happen through accessible publications, research that applies to farms of all kinds, and conferences that specifically invite and cater to the needs of underrepresented groups through relevant sessions, invited speakers, and practical locations, including virtual conferences. To bolster the pipeline of technical advisers from underrepresented backgrounds, training and recruitment could start with the Biden Administration's proposal for a Civilian Climate Corps. Recruits could be trained in conservation and climate-smart agricultural practices with clear pathways to careers in technical assistance or academic study.

Equitable access to agricultural science also depends upon the types of questions under investigation. The graduate student cohort of the Agronomy, Crop, and Soil Science disciplines is the most diverse cross-section of our membership, and they have the potential to elevate issues important to underrepresented groups throughout their scientific careers—issues like environmental justice, climate action, culturally significant crops, and the challenges of small or diversified operations. Unfortunately, there are systemic barriers and inequities in place that discourage students of color from achieving their potential, resulting in a much less diverse cohort of professors leading our fields. USDA can start by bolstering the student pipeline.

Photo: Landowner discusses conservation practices. Lance Cheung, USDA.

Photo left: Institute of American Indian Arts (IAIA) student shares about his research. Lance Cheung, USDA.

Crop Genetic Resources

The United States possesses a considerable and unmatched asset in its network of gene banks, which contain a wealth of crop biodiversity. This natural diversity includes domesticated species of a wide range of crops representing an amazing range of uses and their wild relatives. It provides the foundation for the genetic improvement of crops so that they can tolerate ever more frequent stresses such as high temperatures and variable precipitation, better resist novel or introduced pests and diseases, and yield more nutritious and higher-quality harvests adapted to rapidly changing climates. The genetic resources contained in gene banks are continuously enhanced by targeted botanical explorations, both domestic and abroad, by conservation in specialized infrastructure including ultra-cold storage and live orchards, and by public and private research on genetic diversity, the genetic inheritance of complex traits of economic importance, and the transfer of this diversity into elite climate-resilient crop cultivars. Gene banks are insurance against current and future threats to agricultural production and provide potential new crops that can respond to new human needs, rapidly changing adaptations, and novel economic opportunities.

Photo: Plant tissue cultures.
Lance Cheung, USDA.

Photo right: Minorities in Agriculture, Natural Resources, and Related Sciences (MANRRS) National Officer Team.
Tom Witham, USDA

USDA's Agriculture and Food Research Initiative's (AFRI) individual investigator grants may provide funding for student work, but their 2- to 3-year duration is too short, the award amount too small, and the success rate too low to maintain graduate student interest and involvement. Those who come from disadvantaged backgrounds are less likely to choose a field with unreliable funding. USDA should double AFRI's budget for direct funding for graduate student research and programs, including student fellowships, from 1.5 to between 3 and 5% of its total funding. This will give financial security to students and the ability to choose their own research projects. Additionally, by expanding USDA's current educational programs, such as the Education and Workforce Development Initiative and National Needs Graduate and Postgraduate Fellowship program, and integrating them with USDA's 1890 National Scholars Program, talented students at the 1890s Historically Black Colleges and Universities (HBCUs) and other minority serving institutions (MSIs) would have a streamlined path towards fellowships in the agricultural sciences.

Funding students and focusing on disadvantaged groups will still not be enough to counter the systemic challenges faced by Black, Hispanic, Indigenous, and other scientists of color. Challenges these scientific cohorts face should be assessed at each stage of advanced study to identify and remove roadblocks. Universities should collaborate to undertake discipline-wide analyses of biases and barriers and propose reforms to their tenure tracks that eliminate inequities and encourage a broad range of activities that stimulate mentorship, quality teaching, civic engagement, and local outreach. The value of a diversity of voices cannot be overstated, and their continued absence is an incalculable loss to science and to the planet.

"There are systemic barriers and inequities in place that discourage students of color from achieving their potential, resulting in a much less diverse cohort of professors leading our fields. USDA can start by bolstering the student pipeline."

Encourage diverse collaborations for people, profit, and the planet

It is similarly useful to diversify the types of organizations working together to combat and mitigate the effects of climate change. Unusual collaborations can have unexpected benefits. For example, Ceres Solutions is a farmer-owned cooperative delivering services to farmers in central Indiana and Michigan, and, recently, personnel from its Templeton, IN, location participated in a Soil and Water Conservation District (SWCD) watershed working group. This led Ceres to make a large donation of consulting hours through NRCS's Regional Conservation Partnership Program. Ceres staff leveraged their relationships with farmer customers to improve the use of nutrient management practices and successfully encouraged participation in NRCS Environmental Quality Incentives Program (EQIP) contracts.

In this case, the SWCD understood that Ceres Solutions had trust and influence among producers. Across the breadth of the nation, however, different organizations will have the trust of different farmers of diverse backgrounds and locations. Direct influencers include seed suppliers, crop nutrient and protection suppliers, consultants, bankers or lenders, equipment suppliers, feed suppliers, local Farm Service Agency (FSA) staff, and crop insurance agents. Bringing these groups to the table is the best way to win the trust of the farming community to support conservation practices that mitigate and enable adaptation to climate change.

CCAs may be the most important group to include. They have the closest relationships with growers, are the interface between science and practice, and can integrate transdisciplinary research. They serve growers through public extension, private company agronomy services, and retail channels including all the above examples of direct influencers. Minority serving groups, such as Minorities in Agriculture, Natural Resources, and Related Sciences (MANRRS), the National Black Food and Justice Alliance, and the Northeast Farmers of Color Land Trust, are also valuable partners that bring a different perspective and hold the trust of groups often left out of traditional means of communication.

Multi-institution coalitions that include these groups and others will be vital for delivering essential information about ecosystem services and conservation practices. While coalitions need not include every organization, careful consideration of all the various stakeholders in the food and agricultural system should be given. A supermarket chain, for instance, may not seem like an obvious partner in the development of a research project. Retailers may simply not be interested in the science behind a practice. But it may be useful to include a marketing perspective as the project progresses. Including these groups at the onset promotes a sense of ownership and collective dedication to the projects' goals.

Collaborations across agencies within USDA will also be necessary. USDA should stand up a science advisory committee for climate, perhaps as a subcommittee of the National Agricultural Research, Extension, Education, and Economics (NAREEE) Advisory Board. Additionally, the Secretary of Agriculture should designate a Chief Climate Adviser in charge of, and empowered to, coordinate climate mitigation and adaptation strategies across the Department. The position would be similar to the USDA Chief Scientist but would be placed in the Secretary's office and would not be restricted to matters of science only. For coordinating climate science, USDA can use its interagency Science Council, which is a committee that advises the Secretary on policy matters through a scientific lens. The Science Council supports subcommittees dedicated to interagency coordination in several areas, but none specifically address climate change. Ideally, a climate subcommittee would include climate representatives from agencies and offices across the Department who are empowered to speak for their agencies, set up new initiatives, make substantive changes to existing programs, and support new programs.

As climate change exacerbates the pressures on agricultural producers to do even more with less, the pace of information exchange needs to quicken. To move into the future, collaborations among existing groups should be strengthened, and new, interdisciplinary and multilevel alliances must be formed. This will contribute to the free flow of information to and from the producers on the ground and encourage a more rapid dissemination of best practices.

Photo: Beginning and established farmers at a night seminar on soil conservation.
Lance Cheung, USDA.

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