Testimony of:

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On *"Increasing Resiliency, Mitigating Risk: Examining the Research and Extension Needs of Producers"*
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I would like to start by thanking Chair Stacey Plaskett, Ranking Member Neal Dunn, and members of the Subcommittee for hosting this important hearing. I appreciate the opportunity to share with you my personal views on research and extension needs of producers in a time of increasing climate variability and more extremes in temperature and precipitation. My perspective has been shaped by more than three decades of experience as a faculty member at Cornell University, with a research and extension program focused on soil and water management, and climate change adaptation and mitigation strategies for the agriculture sector. I am very grateful for the grant funding I have received over the years from USDA-NIFA, USDA-SARE, and USDA-Hatch programs. I am also grateful for support from New York State for some of my regional projects, and for the collaboration with many farmers, which has been essential to creating an outreach program that addresses their needs.

In addition to peer-reviewed research and extension publications, my science communication efforts have included analyses relevant to policy-makers, such co-authoring chapters of the 2008 and 2014 National Climate Assessments, and serving as lead author of the Agriculture and Ecosystems chapters of the state-funded study, "Responding to Climate Change in New York State". Currently I am lead project director for the New York Soil Health program (www.newyorksoilhealth.org), am on the Advisory Boards for the New York State Water Resources Institute and the Cornell Institute for Climate Smart Solutions, and teach a course on Climate Change and Food Security.

Farmer Vulnerability to Climate Change

When I became involved in climate change research almost 30 years ago, the evidence for impacts on agriculture was subtle, and we relied heavily on climate and crop model projections to discern future impacts. But unfortunately this new challenge for agriculture has crept up on us more quickly than some expected. Farmers today are feeling the effects in real-time, and having to make difficult decisions to cope. They can no longer rely on weather patterns that for centuries have been characteristic for their region to determine what crop to plant, when to plant it, or how to grow it. In addition to an increase in drought and heat risk in many regions as one might expect with "global warming", there have also been many surprises. Below are a few examples.

Too much water
The frequency of intense rainfall events compared to historical averages has increased in the past 40 years for most regions of the U.S. (Kunkel et al. 2013). In a warmer world, more of the earth's water is in the air as water vapor, so there is more up there to come down during an upper atmosphere condensation event. Too much water can cause direct crop damage or yield losses from disease. When prolonged wet conditions in the spring or fall limit field access during planting or harvest, farmers are not able to take advantage of the climate change trend for a longer frost-free period that has been observed in most regions. Excessive rain also can lead to increased soil erosion, and runoff of sediments, fertilizers, manure, and agriculture chemicals into waterways.

As we meet here today, many farmers in the Great Plains and Midwest are suffering from a particularly severe and record-breaking spring flooding that has delayed planting to the point where, for some, the season will be a total loss (Van Dam et al. 2019). This is what concerns famers the most: extreme weather events that are less predictable, more frequent, sometimes occur in clusters, and are more catastrophic than previous generations have had to face.

For most Americans climate change impacts on food production might mean a shortage or higher price for some of our favorite grocery items. But for the two percent of our population supplying our food, it can have devastating economic consequences. It can force farm families into increasing loan debt, taking part-time work outside the farm, or even selling part or all of the farm. These farmers may not be keeping up with the latest climate change reports or debates, but they are the ones in the trenches, dealing with the challenges on a daily basis.

Drought vulnerability in historically "humid" regions
The Northeast is typical of many humid regions, with summer rainfall usually adequate for production of field crops and hay and forage animal feedstocks. Those producing high value fruit and vegetable crops often have some capacity for supplemental irrigation for at least part of their acreage. But an increased risk of short-term summer drought has been projected for the region, reflecting an increase in crop water needs with longer, warmer summers, combined with projections of little change or a decline in summer precipitation (Wolfe et al. 2018; Hayhoe et al. 2007). The region has not invested in infrastructure to deliver water to farmlands from lakes and reservoirs as is the case in historically more arid regions. The region's vulnerability to drought was made apparent in 2016 when a severe drought reduced yields of rain-fed crops by more than half in many parts of region.. Even those growing high value crops with supplemental irrigation suffered losses, either because they did not have enough equipment to keep up with demand, or because farm wells, ponds, and creeks went dry (Ossowski et al. 2017; Sweet et al. 2017).

The 2016 drought was not the end of the story for the Northeast. The following 2017 growing season was unusually wet, and many of the same farmers suffered crop (and soil) losses from heavy rains and flooding (Sweet and Wolfe 2018).

More cold damage in a warming world?

Another climate change surprise has been an apparent increased risk of cold damage for woody perennials such as apples and grapes in a warming world. This can occur when warmer and more variable late winter temperatures trigger an unusually early bloom that leaves the plant vulnerable to an extended period of frost risk. While frost damage is not a new phenomenon, a lack of synchrony between bloom and spring frost appears to be occurring more frequently in recent years, and a recent modeling study for apples suggests this trend may continue in the Northeast, at least for the next few decades (Wolfe et al. 2018). An example of the impact this can have was seen in 2012 when unusually warm temperatures in late winter led to record-breaking early flowering of many plant species (Ellwood et al. 2013). In that year apple and grape growers in the Northeast lost millions of dollars (Horton et al. 2014). Significant damage to apple buds occurred again in spring 2016 after another mild winter, followed by April frost.

More dynamic and intense pest and weed pressure

We now have overwhelming documentation that the living world is rapidly responding to climate change. Longer, warmer summers can lead to more generations of insect pests per season, and increased competition from weeds. In addition, farmers in higher latitude regions are facing new pests, weeds, and plant pathogens coming up from the south as temperatures warm and the suitable habitat for these species expands northward.

Farm-level adaptation strategies

Many farmers today have seen enough evidence to be convinced that a significant change is going on with the weather patterns; one that will require a proactive, adaptive management to stabilize productivity and remain profitable. The list below provides examples of some key strategies that are being implemented in some areas as ways to build resiliency and reduce risk. (for a more thorough review, see: Walthall et al. 2012; Wolfe 2013).

- *Diversify* with more staggered planting dates, a more diverse crop variety mix, and/or diverse rotation sequences. Explore new crop and market opportunities possible with a longer growing season, and/or in relation to climate change impacts and farmer responses in other regions. This is a way to “hedge bets” in a context of uncertainty.
- *Improving soil health* is a “win-win” approach with multiple benefits, including resilience to climate variability, and capturing and storing carbon in soils (Wolfe 2019). Healthy soils have relatively high organic matter, which provides resilience to short-term droughts, flooding, and compaction. Maintaining vegetation cover as much of the year as possible with fall and winter cover crops—one of the key methods to rebuild organic matter on depleted soils—also has the benefit of reducing erosion losses during heavy rainfall events. And soil organic matter is often more than 60 percent carbon, carbon that otherwise would be in the air as the greenhouse gas, carbon dioxide.

- *Regional Integrated Pest Management* for anticipating and controlling new pests, diseases, and weeds.
- *Better water management*. This could range from building resilience through better soil management, to using new sensors and tools for optimized irrigation scheduling, to capital investment in irrigation or drainage systems.
- *Fruit crop frost protection* begins with site selection at initial planting, and methods during frost events, such as misting or air circulation fans, to reduce damage.
- *Investment in large scale farm equipment* to cover more acreage quickly is a strategy for adapting to smaller windows of opportunity (e.g., between rainfall events) for farm operations such as planting or harvesting.
- *Reduce heat stress in livestock facilities* by improving design of new facilities, or improving existing facilities with better air circulation, or retrofitting with fans and sprinklers, or more sophisticated cooling systems.

Research, Extension, and Policy Needs

The adaptation strategies discussed above focus on farm-level adaptation, but for farmers to be successful they will need support from those beyond the farm. Below are several key needs where researchers, extension and other educators, government agencies, policy-makers, agriculture service providers, non-profit organizations, and communities can play a role.

Climate change science and delivery of information to farmers

Farmers are intimately familiar with the day-to-day weather challenges on their farm, but this information is local and anecdotal. Climate scientists, through extension networks, can provide a broader view that includes data from other regions, historical analyses of trends, and climate projections. This can help farmers identify changes in weather patterns that are part of a long-term trend and warrant investment for adaptation. While some regions have reasonably effective programs for getting this information to farmers, others do not.

Seasonal climate forecasts

More research is needed to improve our ability to provide seasonal climate forecasts, for longer range planning (e.g., the entire growing season). This is particularly needed in regions where the climate is not strongly influenced by ENSO cycles, for example.

Economics of climate change impacts and adaptation strategies

Impact assessments of climate change on the U.S. agriculture sector have often assumed an “autonomous” adaptation by farmers, and largely ignored the risk and costs for the agricultural sector. Also, prior analyses have often focused on the major world food crops such as corn, soybean, and wheat. More attention is needed regarding impacts and costs of adaptation of other agriculture systems, such as high-value fruit and vegetable crops, and livestock, which are major components of the agricultural economy in many regions of the U.S..

Regional centers for coordination and exchange of climate change and adaptation information

This can also increase synergy of efforts among researchers, educators, and farmers. Some land-grant universities, non-profit organizations, and government agencies provide useful information and training for farmers and extension staff, and/or host websites with resources, climate data and decision tools for farmers (e.g. www.climatesmartfarming.org). But these efforts are not available in many parts of the country, and are typically underfunded or discontinued when short-term funding runs out. The current regional USDA climate "hubs" have provided a valuable service recently that is national in scope and been successful at coordinating regional activities, and organizing regional assessments, conferences, and webinars, despite limited funding. Establishing some version of these as a long-term and appropriately funded program of the agency would be a good alternative to what we have today.

Environmental monitoring, data analytics, and digital agriculture
The challenges imposed by climate change demand a radical transformation in information available to farmers for decision-making. The agricultural sector is not taking advantage of satellite and other data sources available, new sensor network technology, and computer systems that can translate massive data into useable information for field-level management decisions on a daily basis and for long term land use planning. To address this will require new collaborations and integrating knowledge from meteorology, climate science, biology, ecology, engineering, and computer science. The public sector can play an important role in ensuring equity of access to all farmers.

Policy incentives and cost-sharing for climate change adaptation and conservation
Many soil and water conservation policies, such as those implemented by the USDA-NRCS EQIP programs, also have relevance to climate change impacts, adaptation, and mitigation. Where appropriate this could warrant an expansion of appropriations through the Farm Bill for some of these programs. Also, these policies should be reviewed for their impact on flexibility required for adaptation to climate change at the farm level.
Various aspects of farm policy could be reviewed in search of mechanisms to facilitate farmer adaptation to climate change without unintended or inequitable negative consequences for farmers, the environment, or markets and trade. Disaster assistance and production or income insurance policies will be an essential component of helping farmers cope with less predictable weather patterns, but the possibility of blending these with incentives for adaptation to avoid adverse impacts of climate change where appropriate deserves study.

Breeding and biotechnology for climate-resilient crop and livestock varieties
Our knowledge of plant and animal genetics, and the development of new molecular-assisted and genetic engineering techniques have increased exponentially in the past few decades. Targeting specific genes or suites of genes for environmental stress tolerance will require continued research to better understand key factors associated with climate change that determine yield. For example, evaluation of historical meteorological and yield data for Midwest grain crops has indicated that increasing minimum nighttime temperatures, as well as daytime heat stress and seasonal precipitation, are factors (Hatfield et al. 2017; Ortiz-Bobea et al. 2019). To date, most effort has been applied to major world food crops such as corn, soybean, wheat, and rice. University and other public sector emphasis should be on high value fruit and vegetable crops

important to the agricultural economy of many regions of the country, but not addressed by commercial seed companies.

Concluding Remarks

Many farmers in the United States are already beginning to change practices to adapt to a less predictable climate. They will need support and access to the latest environmental monitoring technology, as well as weather and climate information, to make timely, strategic farm management decisions. With sustained major investments in research and extension, and policies that facilitate adaptive management, farmers will be better prepared to meet the challenges and take advantage of any opportunities that a changing climate may bring.

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