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EDITORIAL

Navigating climate-related challenges on working lands: a special issue by the USDA Climate Hubs and their partners

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Farmers, ranchers, and forest landowners have seen an increase in risks to their operations in recent decades. The next century is expected to be much more uncertain, with increased atmospheric carbon dioxide driving changes in precipitation and temperature patterns. Working lands and livestock will experience increased biotic and abiotic stressors. These stressors coupled with extreme events and projected future changes to the climate will likely have a detrimental effect on crops, forests, and livestock by midcentury and beyond (Walthall 2013).

Since 1880, global average surface temperatures have increased by 0.94 °C due to the increased production of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) (NASA 2017). Atmospheric CO_2 concentration is at its highest levels in 650,000 years (406 μmol mol^{-1}) (NASA 2017). In addition to the pressures of a changing climate is the growing population projected to increase from 7.5 billion (April, 2017) to 11.2 billion people in the year 2100 that will require sustainable food and water supplies to maintain food and water security (United Nations 2017). There are opportunities for mitigation of climate change, and agriculture and forest systems can play a role given the fact that in 2015 agriculture contributed 9% of the GHG emission to the atmosphere while land-use and forestry offset 11.8% of the total emissions in the USA (EPA 2017). Without a plan to address these challenges, however, producers face limited options, rural economies suffer, the food supply is placed at risk, and the natural resource base is compromised.

Regional Climate Hubs were formed by USDA in 2014 to help connect research to assistance, support, and monitoring programs with the goal to ultimately help land managers adapt to a changing climate. Ten Regional Climate Hubs located across the country support

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farmers, ranchers, forest landowners, resource managers, and rural communities as they plan for and manage climate-and weather-related risks and vulnerabilities. The Climate Hubs are an interagency program led by the Agriculture Research Service (ARS), Forest Service (FS), and Natural Resources Conservation Service (NRCS). The Hubs work through USDA field staff, federal partners, universities, the private sector, and various regional stakeholders to deliver climate information and tools to enable climate-informed decision-making.

Agricultural systems across the US represent a wide diversity in complexity in terms of the crops, forests, and livestock produced with potential to mitigate GHG emissions and each system requiring a different strategy to adapt to a changing climate. Often land managers simply lack the information, tools, or proper incentives to undertake practices that help them to manage impending climate risks, and stabilize production. This special issue was assembled by members and partners of the USDA Climate Hubs to provide sector and region specific research and assessments to their stakeholders so that they might better anticipate and adapt to a changing climate. Adaptation strategies must fit within an individual farm, ranch, orchard, vineyard, or tree lot; however, producers often lack the information required to facilitate the knowledge transfer. As an initial step in this process, the Climate Hubs and their partners assembled a series of papers to address the vulnerabilities for the dominant agricultural systems in each Climate Hub region. Next, Climate Hub staff, leveraging new forms of communications to improve outreach, will identify customer-focused decision-support strategies, and connect new and existing regional networks of technical advisors, researchers, and science communicatorsto enhance working land resilience into the future.

The articles in this issue focus on the specific challenges land managers will face as the climate changes and provide adaptation strategies to help them overcome these challenges. Topics range from assessing the vulnerability of specialty crops in the Midwest, to identifying adaptive strategies for resilient beef and dairy operations in the Caribbean. Across the regions, increasing daytime and/or nighttime temperatures, growing precipitation variability and intensity, shifting growing seasons, and extreme events are forcing farmers, ranchers, and foresters to consider alternative management practices. Some of the adaptation strategies proposed in this issue include investing in equipment to keep confined livestock cool and hydrated, identifying better region and climate-adapted cattle breeds, crop cultivars/tree species, or adopting new management practices.

This special issue focuses by sector on regional climate change effects on working lands and proposes strategies to deal with the associated stressors. Cropland climate vulnerabilities are addressed in the Northeast, Midwest, and Northern Plains regions. The Midwest region's authors cover not only grain crops but also specialty crops– e.g., potatoes, asparagus, green beans, sweet corn, pumpkins, blueberries, apples, and grapes– that constitute a significant portion of the regional economy (estimated at $1.8 billion in 2012). The authors use USDA Risk Management Agency data to demonstrate that weather-related losses vary by state with excessive moisture and drought representing the highest total number of crop insurance claims for loss across the Midwestern states. Looking ahead, shifting seasonality of precipitation with greater likelihood of spring precipitation events could potentially increase the frequency of crop insurance claims for crop loss due to excessive moisture.

The forestry sector is addressed in the Caribbean, Northern Forests, Northern Plains, and Southeast regions. The Caribbean Hub built a machine learning random forest classifier for Puerto Rico's forested areas to analyze the relationship between climatic, socio-economic, and fire history data with fire occurrence and extent from 2003 to 2011. The results indicate future

climate projections of extreme seasons will increase the potential for fire occurrence across larger areas in Puerto Rico.

The Northwest, Northern Plains, and Caribbean Hubs also focused their research on livestock. The Northern Plains article describes the region's exposure to temperature and precipitation trends, inter-annual variability, and extreme events. Researchers from the Northern Plains evaluated the sensitivity of beef cattle production to direct and indirect effects that would be imposed by projected climatic changes. The researchers provide adaptation strategies to minimize the negative consequences of projected changes and maximize beneficial consequences. The authors also explore social learning networks that support integration of experimental and experiential knowledge in the region. Ultimately, they find that context-specific decision-making can be improved through science-management partnerships that recognize multiple production and conservation/environmental goals.

Land managers will need to become increasingly innovative and willing to ask questions about the interactions between climate change and their agricultural enterprise in order to gather the information necessary to successfully adapt to climate change. Concomitantly, pioneering regional partnerships among geneticists, agronomists, animal scientists, meteorologists, universities, government researchers, science communicators, the private sector, and land managers can help to lower barriers to adoption and ensure the latest research, products, tools, and methods are readily available to working land managers. We hope that the articles contained in this special issue shed light on the region and sector-specific vulnerabilities on working lands as well as offer paths forward to help land managers and rural communities build resilience and mitigate risk. With a growing population and finite resources for growing food, feed, and fiber, we believe land managers are up to the challenge if they are provided adequate information and tools to assess potential adaptation strategies.

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