

Report and Recommendations on the Relevance and Adequacy of the Ag Climate Adaption Programs and Activities at USDA

By the National Agricultural Research, Education, and Economics Advisory Board

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Introduction

The National Agricultural Research, Extension, Education and Economics (NAREEE) Advisory Board is statutorily required to perform an annual review of all the agricultural and natural resource research, extension, or education activities funded by the U.S. Department of Agriculture (USDA) to assess their relevance to the Department's established Research, Education and Economics (REE) priorities and to advise USDA on the adequacy of the funding for those activities (7 USC 7613(b)).

The material provided by the agencies encompassing REE was greatly appreciated by the NAREEE Advisory Board. The NAREEE Advisory Board held a meeting at the Jornada Experimental Range in Las Cruces, New Mexico on January 27-29, 2020, to hear presentations from agency and Department leaders in Ag Climate Adaptation and received materials summarizing the work of the agencies.

The NAREEE board considers that overall the breadth and the depth of work on climate adaptation is being well planned and well executed. The work of the REE on climate adaptation is a large part of the REE mission. Because of the way that the National Institute of Food and Agriculture (NIFA) categorizes research projects, the contribution from this NIFA in the overall portfolio of research is much larger than it appears. As we delved deeper, much of the work classified as commodity work is actually on climate adaptation and it would be easy to suggest that their total effort in this arena is similar to the Agricultural Research Service (ARS) on a percentage basis.

Ag Climate Adaption research is a long-term process requiring a long-term commitment of resources as the science and situation evolves. The NAREEE Advisory Board was impressed with the overall process and how well informed the agency leadership was on the outcomes and impacts within their agencies. While detailed suggestions will follow, we want to applaud the agencies on their focus on this critical subject. It is both highly relevant to the success of US agriculture and the enhancement of our environment.

Based on the input from the REE agencies and the overarching synthesis from the USDA Office of the Chief Scientist, the Relevance and Adequacy (R&A) Committee members completed their review of the spectrum of Ag Climate Adaptation programs. It is important to note that the REE agencies have their own robust programmatic review processes in place (Appendix B). The Committee used information from the agencies' existing individual reviews to evaluate the relevance and funding adequacy across all of the agencies collectively. To guide its evaluation, the NAREEE R&A Committee reviewed the Executive Summary and agency inputs with an emphasis on the following questions formulated for R&A reviews.

Since the Board reviewed the Climate and Energy programs and activities in 2017, specific questions related to this review were developed in conjunction with the REE Mission Area.

General Guiding Questions (for all R&A Reviews)

- What is being addressed by this program?
- Have the investments in this program accomplished the goals for which it was developed? Does the research advance agricultural science?
- Is there a complementary and adequate balance of intramural and extramural projects for relevant results?
- Do the current activities in the program achieve the correct balance between short- and long-term research among formula, capacity, competitive, and intramural funding?
- What has this program accomplished relative to the current state of agricultural science?
- What are the information gaps? What does this program area need to do to address the gaps between this program's activities and accomplishments and the current state of agricultural science?
- Is there adequate funding for the program?

2020 Questions on Ag Climate Adaption

- How has REE been responsive to feedback and evolving stakeholder needs?
- How did the REE agencies respond to the climate portion of the 2017 Relevance and Adequacy review on Climate and Energy Needs?
- Taking a forward-looking approach at Ag Climate Adaption....
- What are the research goals that USDA science should focus on? What are the richest areas for exploration in ag climate adaption?
- What areas are facing the biggest risk if they are not able to adapt to changing weather/climate?
- How can USDA more effectively communicate research activities, innovations, and reports supporting ag climate adaption?

Guided by these questions in reviewing the extensive materials provided, the R&A Committee offers the following report. It describes the Committee's observations and assessment of the relevance and funding adequacy of key programming aimed at advancing agricultural and natural resource science, outreach and education, and stakeholder engagement in each of the sub-goals for the theme area of g Climate Adaptation. The Committee notes that the portfolio across REE and within each of its agencies is extensive and cannot be described in detail in this R&A review report. Rather, this report focuses on highlights, offering a broad synthesis of various agency activities, and on emergent themes for which there was strong consensus among the members of the Committee. Finally, the report presents the R&A Committee's recommendations to address gaps and to strengthen further the portfolio of REE in this theme area.

Summary of Recommendations

1. Based on evidence of stakeholder feedback, previous Relevancy and Adequacy reviews, and the clear priorities of the USDA Science Blueprint, it is recommended that existing educational, outreach and communication activities are strengthened and expanded, as this appears to be the weakness of the overall program.

- a. It is vital that a strong connection exist between scientists and stakeholders, including farmers, ranchers, forest managers, and others, to ensure that research remains relevant and is used effectively. In some areas of the country, this connection seems to be weakening due to the downsizing of agency field staff or underfunding of information transfer efforts such as the Climate Hubs. It is evident that the research activities, innovations, and reports are being communicated with stakeholders; however, the efforts could be expanded to include other USDA agencies that interface with stakeholders such as FSA, Natural Resources Conservation Service, Forest Service and Rural Development as well as, Cooperative Extension Service, and national and international cooperators. We believe that better communication and education on all fronts is necessary to teach and communicate with the end user.
 - b. Increase funding to Cooperative Extension for education and outreach to enhance the implementation of new scientific concepts and products to improve climate adaptation. The outreach and communication should be in common terms for wide understanding by industry stakeholders, the public and policymakers. Competitive funding to integrate Extension with research, demonstration, education, and workforce development such as through the current Sustainable Agricultural Systems (SAS) Coordinated Agricultural Projects (CAPs) program of AFRI. Increasing AFRI appropriations and increasing SAS projects is a win for Extension are all potential tools to increase Extension funding.
 - c. Education is also needed for the public at large as social media and non-science-based information is reaching the public concerning genetic modification, hybridization, and livestock impact on climate. USDA should investigate ways to increase traffic to their social media accounts to increase science-based education on climate adaptation, plant and livestock impact, and other means of mitigating future climate change by farmers and ranchers.
 - d. There appears to be an opportunity to increase funding to and/or leverage partnerships between the ERS and NASS with more technical/regional projects conducted by ARS networks and NIFA in evaluating the economic and sociological decisions impacting the adoption of sustainable, and resilient agricultural systems and practices that both mitigate climate change impacts and help farmers, ranchers, and rural communities cope with rapid climate change.
2. While the breadth and depth of work being conducted are to be commended, the importance of research on climate adaptation continues to grow and the base of research conducted now allows real opportunity to expand in many areas and take on new areas including expanding the integrated work that will be required to develop systems that are more resilient under climate stress, as well as improving cultivar adaptation to this stress, and enhancing carbon sequestration through management strategies. This research needs to extend to what is rapidly becoming our most widely irrigated crop in the country, including turfgrass and landscape environment. Additional research is critical to help our urban acres adapt to climate change. Much of the agencies research on forages has focused on natives, but if we are going to enhance adaptation to a changing new climate, we need to increase focus on non-native, adapted plants to that eco-region.
 3. Overall funding for climate adaptation could be increased, as examples, there seems to have been limited funding provided for the climate hubs to engage NIFA and other ARS scientists in this valuable effort. The addition of social science is especially evident in NIFA funded

- projects and has been appropriate. There is a need to enhance collaborations between ARS and universities, especially with Extension, and increase NIFA grant awards to land-grant institutions and appropriate partners (industry, NGO's non-LGU institutions, government labs) to develop agricultural and land management methods, specifically to reduce GHG emissions. While this has occurred, the problems are growing rapidly and further funding in this area is essential.
4. Increase the REE agencies and FS R&D emphasis on resilient agriculture by increasing emphasis on:
 - a. **Effects of climate on soil quality, the soil microbiome, nitrogen management, agricultural product pricing and productive capacity (ARS and ERS).** Invest more in basic research on soil organic matter, holistic animal health, plant/animal interface research and crop rotation, and their relationships to GHG emissions. Support basic research on soil carbon sequestration through cover crop mixes, integration of grazing into row crop production, long-cycle crop rotation, and the feasibility/profitability of integrated farming systems in comparison with specialized agricultural production. This is deserving of the most attention as this information could provide the fundamental knowledge to meet the goal of reducing our carbon footprint by 50%. Our largest acreage of land continues to be dedicated to forage production that is primarily utilized by the ruminant livestock industry. The limited research by REE on the plant/animal interface and how it should be managed differently to adapt to changing climate is underfunded and lacks REE leadership. Research goals should also consider cropping systems from a holistic approach (not just individual practices), integrating various practices and their impact collectively on a cropping system in addition to economic and environmental impact. More precise weather predictions of microclimate are also critical.
 - b. **Effects of climate change on ecosystem services (NIFA and ARS).** While the REE agencies have taken this on, it is a large and expanding area of opportunity and needs special attention to be considered in policy decisions through Natural Resource Conservation Service (NRCS), Bureau of Land Management (BLM), Environmental Protection Agency (EPA) and other agencies. Increase emphasis on Life-Cycle Analysis of recommended alternative farming systems and strategies for GHG mitigation. The fundamentals of measuring and predicting life cycle analysis need enhanced technologies to make them easier and more reliable to use. Provide funding for Climate Hubs to partner with NIFA and other agencies to enhance their impact on regional eco-systems. The concern is that these hubs be funded, integrated with other agencies and staffed at increased levels to better serve the stakeholders and public. Increase ARS and NIFA emphasis on long-term integrated systems research related to GHG mitigation, since a typical project length or funding cycle (five years) will be inadequate to address questions due to complex relationships between production agriculture and GHG emissions. This continues to be an issue and has been discussed elsewhere, but agency solutions still need to be explored. 10-year or longer projects are needed for climate studies.
 - c. **Germplasm breeding programs, effects of climate variability on aquaculture and animal production, negative effects of invasive species, and climate effects on infectious diseases in humans, plants, and animals (NIFA, ARS).** While much progress has been made in these areas, there are areas of great opportunity that

require significant ongoing efforts. Enhance genetic selection for greater resistance to probable threats. Greater heat tolerance, wind resistance, flood tolerance, etc., as well as the fundamental knowledge and technology to accomplish this. Intensified agricultural systems which provide high economic value outputs with corresponding input requirements offer benefits in diet diversity, increases in health and well-being in managed landscapes, and other benefits. The specialty crop research program has seen traction in a better understanding of these systems on climate adaptation and resiliency. Animal research such as genomic intervention strategies for specific livestock diseases and increasing food animal production will create a more sustainable food livestock industry. More financial resources would continue to aid in this effort. There is an ever-increasing need for infrastructure support at Ag Experiment Stations for long-term breeding and evaluation efforts, including breeding faculty and technical support.

- d. Technology advancements have been and continue to be an important component for advancing plant adaptation. Continued efforts to advance the development of new areas including, gene editing, synthetic biology, sequencing, and automated phenotyping continue to be important areas for emphasis.
- e. **Promote use of productive green infrastructure on farms and in developed areas.**
 - i. Green infrastructure applications are very diverse and can address a range of climate-related challenges. On farms and ranches the use of trees and herbaceous vegetation can address a host of issues related to water conservation, water quality protection, and protection of both crops and animals from excessive heat and wind. In urban areas green infrastructure can help address the heat island effect.
 - ii. By increasing the emphasis on incoming generating green infrastructure (i.e., infrastructure that produces food or other marketable products), farmers and ranchers may be able to diversify income. In urban areas it can help provide a buffer from disruptions caused by climate change-driven events as well as various social or economic disruptions. Many current green infrastructure projects involve plants that provide little or no income, while also taking up potentially productive and income-generating space.
- f. **Maintain and seek to expand research on how to manage forests for greater resiliency** to disturbances that are expected to become more common and/or severe with climate change. The most consistently reported concern of forestry stakeholders was the likelihood that climate change will result in more disturbance, including fire, drought, hurricanes and other severe storms, coastal flooding due to sea level rise, and increases in insect outbreaks and disease.
- g. A host of **forest responses** need greater attention, although some good work is currently being done in virtually every area. Specifically, more research is needed aimed at (1) developing plant material better suited to expected stresses, which can involve biotechnology, genetic studies and field trials, (2) providing guidance needed to support assisted migration and selection of appropriate genotypes for commercial forestry applications, and (3) providing guidance on how to manage existing forests for “pre-resilience” to anticipated disturbances.

- h. Strengthen our understanding of the connection between managing for forest resiliency and the quality and quantity of water available for downstream uses, including agriculture and urban consumption.
 - i. As more disturbances occur, and as management practices change to emphasize greater resiliency, what will the impacts be on the quantity and quality of water available for downstream uses such as farming, ranching and urban consumption? Much capacity in forest hydrology research has been lost and this type of research is likely to be needed more than ever in coming years.
5. The agencies are to be applauded for their efforts to make data more accessible and should be encouraged to enhance coordinated efforts across agencies (such as standardizing data reporting) so that it can be used by multiple researchers and enhance communication efforts.
6. Create consistency throughout all agencies in the categorization of climate adaptation projects and increase the ability to bridge the data gathering and interpretation among research projects and agencies, creating a holistic approach. The NIFA commodity classification system underemphasizes the work that the agency provides on climate adaptation.

Responding to Climate Adaptation

As part of the review process, the NAREEE Advisory Board sought feedback on the current state of agriculture climate adaptation research at USDA from the various groups the Board members represent. This included representatives of the 1862 land-grant universities, the 1890 land-grant universities, livestock producers, national forestry groups, social scientists and agricultural economists, farm cooperatives, crop, soil, agronomy, horticulture, plant pathology or weed science societies, conservation groups, and grazing land groups. The feedback was then synthesized into four main categories: Education and Outreach; Soils, Ag Resilience and Cropping Systems; Livestock and Grazing lands Resiliency; and Forestry Resilience.

Education and Outreach

Upon review of current USDA initiatives supporting climate change adaptation research, it is evident that several research programs are addressing the adoption of all sustainable, resilient agricultural systems and practices that both mitigate climate change impacts and help farmers, ranchers, and rural communities cope with rapid climate change. It is also evident that substantial investments in FY 19 have been made across agencies with the primary share going to ARS to support their National Programs with \$49.96 million, followed by the Forest Service (FS) with \$24.27 million, and NIFA with \$10.21 million. The remaining share is distributed to Office of Energy and Environmental Policy (OEEP)/Climate Change Program Office (CCPO) (\$2.89 million), Economic Research Service (ERS) (\$2.83 million), and the National Agricultural Statistics Service (NASS) (\$0.80 million).

Technical efforts have been made by ARS National Research Programs (NP) in the following areas: (1) NP 211 Water Availability and Watershed Management, (2) NP 212 Soil and Air, (3) NP 215 Grass, Forage, and Rangeland Ecosystems, (4) NP 216 Sustainable Agricultural Systems, and (5) NP 301, 303, 304, 305. These programs have implications to stakeholders' adoption of sustainable, and resilient agricultural systems and practices that both mitigate climate change impacts to agricultural lands, forests, and rangelands. NIFA has taken a regional approach to mitigating climate change by partnering

with land-grant institutions such as a collaboration with the University of Idaho looking at climate change issues in the Pacific Northwest by evaluating the adoption and effective use of precision agriculture. The ERS has contributed to climate change adaptation research by evaluating the development, adoption, and management of drought-tolerant corn in the United States. The FS Research and Development (R&D) only addresses the sustainable use of its National Forest System Lands, which includes 193 million acres and hosts the USDA Climate Hubs. The FS is the only agency that proposes to address all stakeholders including rural communities. A function of the FS is to develop and deliver information to stakeholders to increase climate awareness, improve stewardship and resilience of forests and agricultural lands, respond to disasters and extreme weather events, and enhance rural communities. The USDA OEEP Climate Change Program Office is the only program area that specifically addresses implications to rural communities in its responses to climate change.

Climate adaptation education and outreach efforts to farmers and ranchers have partially been addressed through the regional USDA Climate Hubs, which are hosted by the FS and ARS. The Climate Hubs sponsor in-person events, virtual platforms, and publications. Several events have been conducted through these endeavors, it is anticipated that more than 17,000 students using its formal curricula programming with emphasis on dissemination, adoption, and implementation activities are reached. The Climate Hub also provides web-based tools to support sustainable agricultural production and community resilience. Stakeholders utilize the AgRisk Viewer, a tool that allows users to understand the role of long-term climate trends in crop insurance data to support sustainable agricultural production.

The USDA Science Blueprint theme on Ag Climate Adaptation supports the need to continue research efforts that ensure a more resilient agriculture production system in the presence of climate change. Specifically, the USDA Science Blueprint has acknowledged the need to continue research that assesses best management practices in the areas of landscape-scale conservation and management and evaluates the benefits of technology adoption that informs decision making and planning.

The USDA actively communicates research activities, innovations, and reports supporting ag climate adaptation. USDA agencies collectively utilize the following platforms such as data products, web-based tools, social media outlets, press releases, peer-reviewed publications, annual reports, online magazines, e-newsletters, data listserv, blogs, presentations at conference, workshops, in-person events, webinars, virtual platforms, working group products, and publications to reach stakeholders. Despite the multiplicity of communication efforts, there is a perception that the agency is not active in responding to challenges associated with climate change. There is a mismatch between the extensive USDA efforts on climate adaptation and public perception of agency activities on this front. Research without adoption through education and outreach is just research, not creation of public and environmental benefit.

Recommendations

- Based on evidence of stakeholder feedback, previous Relevancy and Adequacy reviews, and the clear priorities of the USDA Science Blueprint, it is recommended that existing educational, outreach and communication activities are strengthened and expanded, as this appears to be the weakness of the overall program. These programs need to be expanded significantly. REE could commission systematic reviews of critical, controversial issues within climate adaptation and publish these along with the data supporting the conclusions/ recommendations. Target audiences would include Congress, but also could include practical topics of keen interest to policy makers and the public.

The medical research field has done this (refer to the Cochrane Collaborative <https://www.cochrane.org/>). Resilient agriculture policy needs to be led by data that is analyzed and interpreted for decision makers by REE agencies.

- It is vital that a strong connection exist between scientists and stakeholders, including farmers, ranchers, forest managers, and others, to ensure that research remains relevant and is used effectively. In some areas of the country, this connection seems to be weakening due to the downsizing of agency field staff or underfunding of information transfer efforts such as the Climate Hubs. It is evident that the research activities, innovations, and reports are being communicated with stakeholders; however, the efforts could be expanded to include other USDA agencies that interface with stakeholders such as FSA, Natural Resources Conservation Service, Forest Service and Rural Development as well as, Cooperative Extension Service, and national and international cooperators. We believe that better communication and education on all fronts is necessary to teach and communicate with the end user.
- Increase funding to Cooperative Extension for education and outreach to enhance the implementation of new scientific concepts and products to improve climate adaptation. The outreach and communication should be in common terms for wide understanding by industry stakeholders, the public and policymakers.
- Education is also needed for the public at large as social media and non-science-based information is reaching the public concerning genetic modification, hybridization, and livestock impact on climate. USDA should investigate ways to increase traffic to their social media accounts to increase science-based education on climate adaptation, plant and livestock impact, and other means of mitigating future climate change by farmers and ranchers.
- There appears to be an opportunity to increase funding to and/or leverage partnerships between the ERS and NASS with more technical/regional projects conducted by ARS networks and NIFA in evaluating the economic and sociological decisions impacting the adoption of sustainable, and resilient agricultural systems and practices that both mitigate climate change impacts and help farmers, ranchers, and rural communities cope with rapid climate change.
- Strengthen our understanding of the connection between managing for forest resiliency and the quality and quantity of water available for downstream uses, including agriculture and urban consumption.
 - As more disturbances occur, and as management practices change to emphasize greater resiliency, what will the impacts be on the quantity and quality of water available for downstream uses such as farming, ranching and urban consumption? Much capacity in forest hydrology research has been lost and this type of research is likely to be needed more than ever in coming years.

Soils, Ag Resilience, and Cropping Systems

The Soils, Ag Resilience, and Cropping Systems category makes up the largest component of expenditures on climate adaptation in the REE. This is an appropriate use of funds as the managed ecosystem where such adaptation plays a role. Soils are a living resource for individual farms, but also for our country and the world. The focus on enhancing soils through cropping systems that capture carbon and retain it in the soil is the emphasis of much of the work being conducted.

Research, by definition, does not always produce the results we hope for. The focus and commitment of REE in this area is appropriate and effectively designed and executed. The program is long-term in nature and while specific examples of success are numerous and well presented, the program is really in its infancy. Substantial progress has been made to develop fundamental knowledge of crop genetics, molecular tools and rapid advancement in sequencing capability that positions the Agencies for rapid impact moving forward. Novel cultivar and germplasm being released by the system across the spectrum of fruits, vegetables, grains legumes and other crops that are more resilient under heat and drought stress than previous cultivars have dramatically impacted the future food supply for the US and world.

The efforts to develop fundamental knowledge in soils to enhance our ability to model hydrological events, future productivity, and to modify our management practices to enhance our soils for future generations has been strong but is unfinished.

The Advisory Board is optimistic that the following key objectives will be met with current operating procedures:

- Synthesize climate research data and scientific information to inform data-driven and science-driven decision making and planning for agriculture, food, forestry and fuel production systems.
- Understand and convey knowledge about the influences of climate change and weather variability on agricultural, forest, and rangelands; stewardship systems and the communities built around them; as well as the products and societal benefits from natural resources.
- Develop knowledge and tools to enable adaptation to climate change and weather variability, to improve the resilience of unmanaged and managed ecosystems, and to optimize the sustainability of agricultural management systems.
- Leverage economic analysis of land use and management, technology adoption, and environmental program design to inform data-driven and science-driven decision making and planning.

The strategies and evidence building correlate well with the objectives. They also provide insight on how to leverage future work (that is like to have a shifting emphasis) with work that has recently been completed.

Strategies:

- Create and contribute to research that addresses the resiliency and vulnerability of agricultural production, natural resource stewardship, and socioeconomic systems to climate change and weather variability.
- Generate peer-reviewed, science-based research and tools supporting data-driven decisions for agriculture, water resources, land, and forest management.
- Identify mechanisms to increase resilience of food and forest product systems after extreme events.
- Evaluate the environmental effects (benefits/limitations) of conservation practices selected for adaptation for climate change and weather variability or greenhouse gas mitigation. Use this evaluation for a spatially explicit analysis of the economic costs and benefits from conservation practice implementation.

- Develop deeper knowledge of the human dimensions of climate change and weather variability, including perceptions and effective framing of risk, adaptation and mitigation incentives and the impact of climate change and weather variability on nutritional characteristics of food products.
- Examine the economic effects of climate change and weather variability on communities and agricultural producers to enable the development of appropriate/effective technologies.
- Facilitate public/private partnerships to leverage synergies, unique resources and capacities across systems that are directed toward a shared vision/outcome set.

Evidence building:

- Enhance soil-health metrics, with a focus not only on land for crop and animal production, but also forests, grasslands, and rangelands.
- Improve metrics from earth observations for identifying, measuring, and monitoring the effects of climate change and weather variability.
- Identify gaps in USDA observational networks (GRACenet, LTAR, FIA, EFRs) in which USDA is missing data and identify opportunities to utilize existing external datasets to fill these gaps.
- Assess the likely influences of climate change and weather variability on regional and global food, fuel, and forest security.

Especially for NIFA, the funding balance has swung strongly to extramural activities. Some of the long-term objectives of climate adaptation would be easier to execute with an increase in the proportion of intramural funding. The program directors are to be commended for developing extramural funding programs that are working well as a system to move long-term goals forward, however critical assessment is limited

While the breadth and depth of work being conducted are to be commended, the importance of this area of work continues to grow and the base of research conducted now allows real opportunity to expand in many areas and take on new areas including expanding the integrated work that will be required to develop systems that are more resilient under climate stress, as well as improving cultivar adaptation to this stress, and enhancing carbon sequestration through management strategies. This research needs to extend to what is rapidly becoming our most widely irrigated crop in the country our landscape environment, including turf grass). Additional research is critical to help our urban acres adapt to climate change. Much of the agency forage work has focused on natives, but if we are going to enhance adaptation to a changing new climate, we need to increase focus on non-native adapted plants at least to that eco-region.

Stakeholder response is a big part of agency operations and has been considered relative to climate adaptation.

In reviewing the suggestions from the last review, several are still pertinent and require additional action by REE.

1. Increase the integration of energy and climate goals across program offerings. An example would be promotion of strategic partnerships between universities, private industries, and venture capitalists to advance clean energy innovation that aids in adaptation to climate variability and change. Advance regional and national scale initiatives and promote sharing of data and information to address important climate change issues. As an example, there seems to have been limited funding

provided for the climate hubs to engage NIFA and other ARS scientists in this valuable effort. The addition of social science is especially evident in NIFA funded projects and has been appropriate.

2. Increase the REE agencies and FS R&D emphasis on:
 - Effects of climate on soil quality, agricultural product pricing and productive capacity (ARS and ERS);
 - Effects of climate change on ecosystem services (NIFA and ARS); While the REE agencies have taken this on, it is a large and expanding area of opportunity and needs special attention to drive policy decisions through Natural Resources and Conservation Service (NRCS), Bureau of Land Management (BLM), Environmental Protection Agency (EPA) and other agencies.
 - Germplasm breeding programs, effects of climate variability on aquaculture and animal production, negative effects of invasive species, and climate effects on infectious diseases in humans, plants, and animals (NIFA, ARS). While much progress has been made in these areas, there are areas of great opportunity that require significant ongoing efforts. The agencies are to be applauded for their efforts to make data more accessible and standardizing data reporting so that it can be used by multiple researchers.
 - Technology advancements have been an important component for advancing plant adaptation and continued efforts to advance the development of new areas including, gene editing, synthetic biology, sequencing, automated phenotyping continue to be important areas for emphasis.
3. Enhance collaborations between ARS and universities, especially with Extension, and increase NIFA grant awards to land-grant institutions to develop agricultural and land management methods, specifically to reduce GHG emissions. While this has occurred, the problems are growing rapidly and further funding in this area is essential.
4. Increase emphasis on Life-Cycle Analysis of recommended alternative farming systems and strategies for GHG mitigation. The fundamentals of measuring and predicting life cycle analysis need enhanced technologies to make them easier and more reliable to use.
5. Increase ARS and NIFA emphasis on long-term integrated systems research related to GHG mitigation, since a typical project length or funding cycle (five years) will be inadequate to address questions due to complex relationships between production agriculture and GHG emissions. This continues to be an issue and has been discussed elsewhere, but agency solutions still need to be explored.
6. Invest more in basic research on soil organic matter, holistic animal health, and crop rotation, and their relationships to GHG emissions. Support basic research on soil carbon sequestration through cover crop mixes, integration of grazing into row crop production, long-cycle crop rotation, and the feasibility/profitability of integrated farming systems in comparison with specialized agricultural production. This is perhaps deserving of the most attention as this information could provide the fundamental knowledge to meet the goal of reducing our carbon footprint by 50%.

As the Board took a forward-looking approach at Ag Climate Adaption, they identified several research goals to focus on.

Our largest acreage of land continues to be dedicated to forage production that is primarily utilized by ruminant livestock industry. The limited research by REE on the plant animal interface and how it should be managed differently to adapt to changing climate is underfunded and lacks REE leadership. Research goals should also consider cropping systems from a holistic approach (not just individual practices), integrating various practices and their impact collectively on a cropping system in addition to economic and environmental impact. More precise weather predictions or microclimate is also critical.

Intensified agricultural systems which provide high economic value outputs with corresponding input requirements offer benefits in diet diversity, increases in health and well-being in managed landscapes, and other benefits. The specialty crop research program has seen traction in a better understanding of these systems on climate adaptation and resiliency. More financial resources would continue to aid in this effort.

The agency should place an emphasis on the interpretation of research data in common terms for wide understanding by industry stakeholders, the public and policymakers. There may be some resistance to entering the policy area, but there must be tighter integration and interpretation provided by the researchers to policymakers so the policymakers can better understand the implications of policy decisions. Research should also include the ability to bridge the data gathering and interpretation among all research projects and across all agencies, creating a holistic approach.

Livestock and Grazing land Adaptation

Grazing lands are our largest land use; these forage production systems are primarily utilized by ruminant livestock. The limited research by REE on the plant animal interface and how it should be managed differently to adapt to changing climate is underfunded and lacks REE leadership. Research goals should also consider the integration of livestock into cropping systems from a holistic approach (not just individual practices), in addition to economic and environmental impact.

Much of the nation's grazing land is not currently capable of maximizing livestock production due to plant species either planted as forage or site invasion by plants with limited forage value.

- a. The majority of forage species on nation's pastures require little to limited active management to establish and dominate a site. These species typically limit animal production due to limited forage quality, limited production capability, and seasonal toxicity.
- b. A coordinated effort is needed to scope out the problem, identify opportunity cost associated with limited production, and identify or develop potential improved forage systems that maximize site productivity with limited energy inputs.
- c. Will likely require economic evaluation of potential acre with losses due to existing species and return on investment for replacement with new more productive species
- d. Will need to show return on grazing management. This is not a standard practice in the industry

The nation's grazing lands provide ecosystem services to society. Among those are food and fiber, clean air, clean water, carbon sequestration, open space, and biodiversity. How can the services be measured especially as they relate to management? Will the management of these ecosystem services allow for climate adaptation? Some of the key issues that need to be addressed to answer these questions are listed below.

- Identify key metrics to measure grazing land health and evaluate intuitive, rapid tools and technologies to measure those metrics.
- Identify core data needed to measure management impacts on resource management concerns and ecosystem services and measure the economic impacts of those management strategies to producers.
- How does the measurement of the key metrics of grazing land health on a local farm basis relate to landscape level measurements, and should each have its own set of metrics?

- Develop a process to standardize data from farm-based observation and field testing so it can be used in any application.
- Identify existing observations or data to assist in completing Ecological Site Descriptions.
- Does the successful long-term implementation of prescribed grazing impact resource management concerns that require the use of other management practices, and what is the economic impact of the potential reduction in the application of those other secondary management practices?
- Promote and demonstrate the use of both prescribed grazing management and targeted grazing management. Ensure existing described research benefits of multi-species are promoted to ensure proper management of grazing lands, both private and public.

The stakeholder's concerns regarding both livestock and rangeland adaptation:

1. The move to plant-based diet and concern of livestock driving global climate change being fear driven and not based on research. Education of the public is imperative.
2. Adaptation of livestock to new, dryer rangeland.
3. Continued research on how farmers and ranchers can be good stewards of the land and help with carbon sequestration.

Forest Resiliency

It is vital that a strong connection exist between scientists and stakeholders, including farmers, ranchers, forest managers, and others, to ensure that research remains relevant and is used effectively. In some areas of the country this connection seems to be weakening due to downsizing of agency field staff or underfunding of information transfer efforts such as the Climate Hubs. There is a need to maintain and seek to expand two-way communication and information transfer functions, including through the Climate Hubs.

Green infrastructure applications are very diverse and can address a range of climate-related challenges. On farms and ranches, the use of trees and herbaceous vegetation can address a host of issues related to water conservation, water quality protection, and protection of both crops and animals from excessive heat and wind. In urban areas, green infrastructure can help address the heat island effect.

By increasing the emphasis on productive green infrastructure (i.e., infrastructure that produces food or other marketable products), farmers and ranchers may be able to diversify income. In urban areas it can help provide a buffer from disruptions caused by climate change-driven events as well as various social or economic disruptions. Many current green infrastructure projects involve plants that provide little or no income, while also taking up potentially productive and income-generating space.

Forestry-Specific Recommendations:

The most consistently reported concern of forestry stakeholders was the likelihood that climate change will result in more disturbance, including fire, drought, hurricanes and other severe storms, coastal flooding due to sea level rise, and increases in insect outbreaks and disease. USDA, REE and FS need to maintain and seek to expand research on how to manage forests for greater resiliency to disturbances that are expected to become more common and/or severe with climate change

A whole host of responses need greater attention, although some good work is being done in virtually every area already. Specifically, we need to conduct more research aimed at (1) developing plant material better suited to expected stresses, which can involve biotechnology, genetic studies and field

trials, (2) providing guidance needed to support assisted migration and selection of appropriate genotypes for commercial forestry applications, and (3) providing guidance on how to manage existing forests for “pre-resilience” to anticipated disturbances.

As more disturbances occur, and as management practices change to emphasize greater resiliency, what will the impacts be on the quantity and quality of water available for downstream uses such as farming, ranching and urban consumption? Much capacity in the area of forest hydrology research has been lost and this type of research is likely to be needed more than ever in coming years. USDA, REE and FS need to strengthen our understanding of the connection between managing for forest resiliency and the quality and quantity of water available for downstream uses, including agriculture and urban consumption.

Recommendations

The Board initially developed specific recommendations for soil and cropping systems, livestock and grazing land adaption and forest resiliency, however; the issues impacting these areas are very similar. Ultimately, the Board identified the following group of recommendations related to these areas.

1. While the breadth and depth of work being conducted are to be commended, the importance of research on climate adaptation continues to grow and the base of research conducted now allows real opportunity to expand in many areas and take on new areas including expanding the integrated work that will be required to develop systems that are more resilient under climate stress, as well as improving cultivar adaptation to this stress, and enhancing carbon sequestration through management strategies. This research needs to extend to what is rapidly becoming our most widely irrigated crop in the country, including turfgrass and landscape environment. Additional research is critical to help our urban acres adapt to climate change. Much of the agencies research on forages has focused on natives, but if we are going to enhance adaptation to a changing new climate, we need to increase focus on non-native, adapted plants to that eco-region.
2. Overall **funding for climate adaptation could be increased**, as examples, there seems to have been limited funding provided for the climate hubs to engage NIFA and other ARS scientists in this valuable effort. The addition of social science is especially evident in NIFA funded projects and has been appropriate. There is a need to enhance collaborations between ARS and universities, especially with Extension, and increase NIFA grant awards to land-grant institutions and appropriate partners (industry, NGO’s non-LGU institutions, government labs) to develop agricultural and land management methods, specifically to reduce GHG emissions. While this has occurred, the problems are growing rapidly and further funding in this area is essential.
3. Increase the REE agencies and FS R&D emphasis on resilient agriculture by increasing emphasis on:
 - a. **Effects of climate on soil quality, the soil microbiome, nitrogen management, agricultural product pricing and productive capacity (ARS and ERS).** Invest more in basic research on soil organic matter, holistic animal health, plant/animal interface research and crop rotation, and their relationships to GHG emissions. Support basic research on soil carbon sequestration through cover crop mixes, integration of grazing into row crop production, long-cycle crop rotation, and the feasibility/profitability of integrated farming systems in comparison with specialized agricultural production. This is deserving of the most attention as this information could provide the fundamental knowledge to meet the goal of reducing our carbon footprint by 50%. Our largest acreage of land continues to be dedicated to forage production that is primarily utilized by the ruminant livestock industry. The limited research by REE on the plant/animal

interface and how it should be managed differently to adapt to changing climate is underfunded and lacks REE leadership. Research goals should also consider cropping systems from a holistic approach (not just individual practices), integrating various practices and their impact collectively on a cropping system in addition to economic and environmental impact. More precise weather predictions of microclimate are also critical.

- b. **Effects of climate change on ecosystem services (NIFA and ARS).** While the REE agencies have taken this on, it is a large and expanding area of opportunity and needs special attention to be considered in policy decisions through Natural Resource Conservation Service (NRCS), Bureau of Land Management (BLM), Environmental Protection Agency (EPA) and other agencies. Increase emphasis on Life-Cycle Analysis of recommended alternative farming systems and strategies for GHG mitigation. The fundamentals of measuring and predicting life cycle analysis need enhanced technologies to make them easier and more reliable to use. Provide funding for Climate Hubs to partner with NIFA and other agencies to enhance their impact on regional ecosystems. The concern is that these hubs be funded, integrated with other agencies and staffed at increased levels to better serve the stakeholders and public. Increase ARS and NIFA emphasis on long-term integrated systems research related to GHG mitigation, since a typical project length or funding cycle (five years) will be inadequate to address questions due to complex relationships between production agriculture and GHG emissions. This continues to be an issue and has been discussed elsewhere, but agency solutions still need to be explored.
- c. **Germplasm breeding programs, effects of climate variability on aquaculture and animal production, negative effects of invasive species, and climate effects on infectious diseases in humans, plants, and animals (NIFA, ARS).** While much progress has been made in these areas, there are areas of great opportunity that require significant ongoing efforts. Enhance genetic selection for greater resistance to probable threats. Greater heat tolerance, wind resistance, flood tolerance, etc., as well as the fundamental knowledge and technology to accomplish this. Intensified agricultural systems which provide high economic value outputs with corresponding input requirements offer benefits in diet diversity, increases in health and well-being in managed landscapes, and other benefits. The specialty crop research program has seen traction in a better understanding of these systems on climate adaptation and resiliency. More financial resources would continue to aid in this effort.
- d. **Technology advancements** have been an important component for advancing plant adaptation and continued efforts to advance the development of new areas including, gene editing, synthetic biology, sequencing, automated phenotyping continue to be important areas for emphasis.
- e. **Promote use of productive green infrastructure on farms and in developed areas.**
 - i. Green infrastructure applications are very diverse and can address a range of climate-related challenges. On farms and ranches the use of trees and herbaceous vegetation can address a host of issues related to water conservation, water quality protection, and protection of both crops and animals from excessive heat and wind. In urban areas green infrastructure can help address the heat island effect.

- ii. By increasing the emphasis on incoming generating green infrastructure (i.e., infrastructure that produces food or other marketable products), farmers and ranchers may be able to diversify income. In urban areas it can help provide a buffer from disruptions caused by climate change-driven events as well as various social or economic disruptions. Many current green infrastructure projects involve plants that provide little or no income, while also taking up potentially productive and income-generating space.
 - f. **Maintain and seek to expand research on how to manage forests for greater resiliency** to disturbances that are expected to become more common and/or severe with climate change. The most consistently reported concern of forestry stakeholders was the likelihood that climate change will result in more disturbance, including fire, drought, hurricanes and other severe storms, coastal flooding due to sea level rise, and increases in insect outbreaks and disease.
 - g. A host of **forest responses** need greater attention, although some good work is currently being done in virtually every area. Specifically, more research is needed aimed at (1) developing plant material better suited to expected stresses, which can involve biotechnology, genetic studies and field trials, (2) providing guidance needed to support assisted migration and selection of appropriate genotypes for commercial forestry applications, and (3) providing guidance on how to manage existing forests for “pre-resilience” to anticipated disturbances.
4. The agencies are to be applauded for their efforts to make data more accessible and should be **encouraged to enhance coordinated efforts across agencies** (such as standardizing data reporting) so that it can be used by multiple researchers and enhance communication efforts.
 5. **Create consistency throughout all agencies in the categorization of climate adaptation projects** and increase the ability to bridge the data gathering and interpretation among research projects and agencies, creating a holistic approach. The NIFA commodity classification system underemphasizes the work that agency provides on climate adaptation.

**Report Developed by the Ag Climate Adaptation Relevance and Adequacy
Committee, a subcommittee of the NAREEE Advisory Board**

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Appendix A

Review Process

The NAREEE Advisory Board is statutorily required to perform an annual review of all the agricultural and natural resource research, extension, or education activities funded by the U.S. Department of Agriculture to assess their relevance to the Department’s established Research, Education and Economics (REE) priorities and to advise USDA on the adequacy of the funding for those activities (7 USC 7613(b)). This annual process is called the Relevance and Adequacy (R&A) review.

- (b) Advisory Board review:** *On an annual basis, the Advisory Board shall review—*
- (1) The relevance to the priorities established under section [7612 \(a\)](#) of this title of the funding of all agricultural research, extension, or education activities conducted or funded by the Department; and*
 - (2) The adequacy of the funding.*

As the foundation for the R&A review, the USDA Strategic Plan articulates a comprehensive vision for the Department. Priorities directly related to science, education, and information are identified through the USDA Science Blueprint, which describes a set of strategies and actions that relate to a theme area. The USDA Science Blueprint describes seven Action Goals that reflect the full scope and variety of REE activities; several Goals have sub-goals to provide programmatic emphasis.

Theme 1	Sustainable Ag Intensification
Theme 2	Ag Climate Adaption
Theme 3	Food and Nutrition Translation
Theme 4	Value Added Innovations
Theme 5	Ag Science Policy Leadership

Under the revised NAREEE R&A review process, every year the Board organizes an R&A review Committee to focus on one or two of the themes identified in the USDA Science Blueprint with the intention of reviewing all five theme areas over the course of five years. The review includes the programs and activities of all four REE agencies—the Agricultural Research Service (ARS), the Economic Research Service (ERS), the National Agricultural Statistics Service (NASS), and the National Institute of Food and Agriculture (NIFA)—as well as the U.S. Forest Service (FS) Research and Development (R&D) program, as necessary. As noted above, the Board members evaluate the programs on the basis of relevance, quality, and performance and also advise on the adequacy of funding for those programs.

The NAREEE Advisory Board is comprised of 15 members who represent a broad range of disciplines, stakeholder interests, and geographical locations. In addition, the Board membership is purposefully transient, with members serving staggered terms of three years. Under these conditions, the Board members consistently have sufficient collective knowledge of the priority areas being reviewed, and the proposed review process takes this into consideration by utilizing the members with the relevant experience for the priority areas being reviewed.

Background

The mission of the USDA is to provide leadership on food, agriculture, natural resources, rural development, nutrition and related issues based on sound public policy, the best available science, and efficient management. The REE mission is to deliver the scientific discovery and advance scientific

knowledge related to agriculture through research, extension and education. The following agencies directly support this effort:

The **Agricultural Research Service (ARS)** is the largest intramural research agency of USDA. ARS has a workforce of approximately 8,000 employees, including 2,200 life and physical scientists, engineers, and veterinarians who represent a wide range of disciplines and work at more than 90 locations across the country and at five overseas laboratories. The ARS research agenda is broad, with about 750 research projects organized under 4 major program areas: Nutrition, Food Safety, and Quality; Animal Production and Protection; Natural Resources and Sustainable Agricultural Systems; and Crop Production and Protection.

The **Economic Research Service (ERS)** is a federal statistical agency providing economic information, analysis, and research on a wide range of topics related to the agriculture sector. The mission of ERS is to conduct high-quality, objective economic research to inform and enhance public and private decision making related to agriculture, food, the environment, and rural development. ERS research is disseminated through ERS reports and an Amber Waves magazine, data products, peer-reviewed journal articles, and briefings. In addition, ERS routinely responds to staff analysis requests from other USDA agencies, other federal departments, as well as state and local governments to enhance dissemination of information and understanding of research results for use in policy making. Finally, ERS provides information to the USDA stakeholder community at large, including media outlets, academic institutions, non-profit organizations, and more. ERS has offices in Washington, DC and Kansas City, MO with a staff of economists and social scientists who work closely with other agencies and researchers to deliver high-quality, scientifically rigorous research to the policy community.

The **National Agricultural Statistics Service (NASS)** is USDA's statistical agency. NASS conducts hundreds of surveys every year and prepares reports covering virtually every aspect of U.S. agriculture. The statistical data provided by NASS is essential to the public and private sectors for making effective policy, production, and marketing decisions on a wide range of agricultural commodities. NASS also conducts statistical science research on survey design, sampling, and other methodological issue areas. NASS works closely with the states in determining their agricultural profiles.

The **National Institute of Food and Agriculture (NIFA)** is the primary extramural research, education, and extension funding agency of USDA. Its mission is to invest in and advance agricultural research, education, and extension to solve societal challenges. Some of funding opportunities are specific to the Land-Grant University System, and others open to participation by other academic institutions, government agencies, non-governmental organizations, and even private sector entities.

Climate Hubs

The Regional Climate Hubs Charter mandates that the Executive Committee conduct a performance review of the program every 5 years, and that the Climate Hubs National Lead chair the 5-Year Review process.

The *purposes* of this 2014-2019 review are to: (1) evaluate and assess the efforts of the Hubs as they relate to the Hubs' mission, vision, approach, and functions stated in the Hubs' Charter, and (2) evaluate the Hubs' ability to adapt to the changing needs of their internal and external stakeholders.

The *objectives* of this review are to: (1) provide an assessment of the Hubs' accomplishments and related impacts from 2014 to 2019, including their effectiveness in identifying and capitalizing on

opportunities to provide meaningful information and tools to internal and external stakeholders, and (2) develop a set of recommendations based on identified opportunities to guide future direction.

The following highlights findings of the 5-year review:

Review Findings

1. **The Climate Hubs excel at outreach, partnership building, and as a convening body.** The Hubs provided a platform for USDA agencies to meet and work on common issues and expand USDA outreach with partners and working lands managers.
2. **Information produced by the Hubs, which is distributed in multiple formats, effectively expands working knowledge of climate and adaptation in the field.** The Hubs synthesized regional climate impacts, identified how climate variability affects land management, and communicated this information in effective ways.
3. **The Hubs successfully work with partners to leverage funds to address pressing needs in their regions.** The Hubs worked with an array of partners, including USDA agencies, University Extension, and a broad range of other Federal Agencies, including the National Oceanic and Atmospheric Administration (NOAA) and the Department of the interior (DOI).
4. **The Hubs increasingly work with new audiences to help build climate resilience across the country.** By reaching out to tribes, tribal and inter-tribal organizations, 4-H, and K-12 schools, the Hubs helped these groups identify regional and culturally relevant climate adaptation opportunities and educate the next generation of a climate smart workforce.
5. **The Climate Hubs Fellows are a critical resource for the Hubs teams.** The Fellows provided significant levels of research, training, and outreach support to the activities of the Hubs.

Appendix B

Existing REE Agency Program Accountability Processes

In conducting the R&A review, it is important for the NAREEE Board to understand the existing program review processes and why the Advisory Board can rely on these processes to support their review. There is a mix of scientific, statistical, and external research support functions within the REE mission area. Program evaluations are tailored to best examine the effectiveness and efficiency of each of the agencies. These evaluations also contribute to continuous program improvement. Each of the REE agencies, as well as the FS, has robust and rigorous processes in place for program planning and evaluation. As part of the agency reviews, groups of highly regarded individuals in the research community are asked to perform independent, competent review of the technical and scientific merit and quality of the research. Nomination of an expert as a qualified reviewer is a distinguished recognition of the individual's professional accomplishments in his or her field of endeavor. Experts are also evaluated based on their independence so that they can maintain objectivity. The charges given to these panels are to evaluate the programs based on relevance, quality, and performance:

- The relevance criterion seeks to assess whether the research activity is appropriate in relation to the REE mission + FS, USDA, and priorities related to the field of study, and current and anticipated stakeholder needs.
- The quality criterion seeks to ensure that the program maintains practices to ensure the performance of high-quality research consistent with standards within the discipline.
- The performance criterion seeks to ensure that REE management measures and tracks progress toward meeting program goals and provides evidence of the impact of its broad research program.

A brief description of each of the agency and mission area program evaluation processes follows. A more thorough description of program evaluation processes for the REE agencies is available through supporting documentation.

ARS

ARS uses a 5-year planning and review cycle that includes the four major program areas: Nutrition, Food Safety, and Food Quality; Animal Production and Protection; Natural Resources and Sustainable Agricultural Systems; and Crop Production and Protection. As a first step, stakeholder input is solicited to develop an overarching National Action Plan. Plans to develop supporting research projects go through external quality review and evaluation prior to approval and are then implemented with annual reports over the 5-year cycle. An external panel is convened for retrospective review after project completion to assess outcomes and impacts.

ERS

ERS is organized around three research program divisions: Resource & Rural Economics; Food Economics, and Market & Trade Economics. ERS uses a 1-3 year planning cycle across its five broad research program areas to be responsive to current policy and industry issues as they evolve. The planning process includes determining the scope and available resources for each program area, soliciting stakeholder feedback on program priorities and emerging issues, and developing new priority research projects on existing and emerging issues to meet the information needs of our customers. For program review, ERS then commissions an external review panel each year to review one of the five research program areas on a rotating basis so that all program areas are reviewed once within a 5-year program review cycle. The external panel of experts provides feedback on the relevance, quality, and

performance of the program area and ERS uses that feedback to refine the program area during the next planning cycle. ERS also conducts additional data and sub-program review exercises as appropriate.

NASS

NASS has organized itself into seven Divisions (Statistics, Census and Survey, Methodology, Research and Development, National Operations, Field Operations, and Information Technology). Each Division has its own accountability process and to ensure each Division's accountability NASS has established the various councils and committees detailed below. NASS also has the Agricultural Statistics Board (ASB) that is chaired by the Director of Methodology Division, while the Director of Statistics Division serves as the Executive Director. The ASB is accountable for the methodology process, statistical integrity, and data security for official NASS reports. Additionally, a monthly Senior Executive Team (SET) meeting is held to provide guidance and leadership.

NIFA

NIFA's science objectives are developed, delivered and evaluated through science, education, and extension programs, which are managed by teams of National Program Leaders (NPLs). Each portfolio team develops priorities and performance measures that align with NIFA, REE, and USDA Strategic objectives. Portfolios are managed through a USDA-approved science planning and evaluation cycle. Portfolios are the basis for a 5-year planning and assessment cycle. NIFA's portfolios are reviewed beginning with stakeholder input and ending with an independent external review.

USDA OEEP – Climate Change Program Office

In 2018, the USDA **Climate Change Program Office** (CCPO) was combined with the offices of Energy Policy and New Uses and Environmental Markets to form the USDA **Office of Energy and Environmental Policy** within the Office of the Chief Economist. The Climate Change Program coordinates USDA's responses to climate change, focusing on implications for agriculture, forests, grazing lands, and rural communities. Responses include adapting to changes as they occur and improving operational greenhouse gas efficiencies. CCPO is a source of objective analytical assessments and proposed response strategies, ensuring that programmatic initiatives are informed by the latest research and that the Federal research enterprise leads to actionable science for the Department and our stakeholders for informed decision-making. CCPO interacts with other Federal agencies and the legislative branch on climate change issues affecting agriculture and forestry and represents USDA on U.S. delegations to international climate change discussions. The CCPO was established under the statutory authority of the Global Climate Change Prevention Act of 1990. CCPO chairs the USDA Global Change Task Force which meets monthly to coordinate USDA climate change goals and Agency actions.

To ensure that USDA's scientific climate change and adaptation efforts anticipate and meet stakeholder needs, OEEP regularly participates in forums and solicits input from stakeholders inside federal, state, and local governments; with the private sector; producer and trade groups; environmental organizations; universities; academic institutions; carbon markets organizers and participants; international representatives and representatives of other governments; and renewable energy organizations. These efforts include meetings, virtual forums, webinars, workshops, publications, field demonstrations, and at scientific conferences.

Climate Hubs: In February 2014, the USDA announced the launch of "Regional Hubs for Risk Adaptation and Mitigation to Climate Change." These regional centers connect USDA science to USDA program agencies, work with partners to support decision-making, and communicate regional risks and vulnerabilities through their stakeholder networks, providing two-way communication between field

staff and researchers. This program provides Hubs field staff with science-based knowledge, practical information, and tools they can share with producers to meet region-specific climate-related needs.

Through science assessment and syntheses, technology and tool development, and outreach and education, the Hubs leverage agency investments to build regional responses to climate variability. The Hubs embody Secretary Perdue's OneUSDA model, and support broad outreach goals shared by the Agricultural Research Service (ARS), Natural Resources Conservation Service (NRCS), U.S. Forest Service (USFS), National Institute of Food and Agriculture (NIFA), Animal and Plant Health Inspection Service (APHIS), Farm Service Agency (FSA), Risk Management Agency (RMA), Rural Development (RD), and the Office of the Chief Economist (OCE).

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Appendix C

USDA Science Blueprint Theme: Ag Climate Adaptation

The USDA Science Blueprint is a strategic document that is scheduled for release in early February 2020. The Blueprint is an expression of policy used to help guide each agency in its strategic planning process and review. The Blueprint lays out overarching themes that provide a framework for our vision for the USDA's science initiatives. The goal of setting forth this framework is to provide organizational clarity, speed and agility to meet the needs of today's and tomorrow's agricultural enterprise. The Blueprint is intentionally concise and customer-focused so that we can build on the trust USDA science holds with stakeholders in the United States and around the world as well as be assertive as leaders in agricultural science and innovation.

Here is a preview of the Theme Ag Climate Adaptation:

Ensuring that agricultural lands, national forests, and private working lands are conserved and restored makes agriculture production more resilient to climate change and other disturbances such as drought, invasive species, and wildfire. Further, based on the best available science, new strategies and management practices must be developed to allow unmanaged and managed systems to be fully leveraged to mitigate and address climate change. While mitigation is a priority, agricultural systems must nonetheless adapt to the changing weather patterns and temperature regimes to ensure food security.

Landscape-scale Conservation and Management

Objectives:

- Develop interdisciplinary integrative systems approaches to address environmental and management challenges that positively impact productivity and resilience.
- Consider abiotic factors such as nutrient and water cycles and all biotic trophic levels, including microbiomes, invertebrates, and roots as elements of a healthy ecosystem.
- Better understand the effects of management choices and climate change on soil and air quality, and water cycles at landscape scales to inform land managers and policymakers.
- Develop methodologies for the combined use and evaluation of novel sensing technologies and land management practices to increase resilience, input-use efficiency, and productivity.
- Work with communities and stakeholders to understand needs, identify barriers, quantify ecosystem services, and promote technology transfer and innovation.

Strategies:

- Generate mission-driven initiatives and interdisciplinary research that incorporates stakeholder inputs to increase the use of best management practices, innovative technologies and tools to promote resilient farms, forests, and rangelands, and improve ecosystem services.
- Develop avenues for open data access to facilitate trans-disciplinary research, stakeholder engagement, and the co-development of research and management recommendations.
- Invest in research and development, education, and extension activities to better understand whole ecosystem responses to environmental challenges following agricultural activities.

Evidence building:

- Assess the communication, adoption, and implementation of best management practices for the stewardship of productive, resilient and sustainable agricultural lands, forests, and rangelands.
- Make cross-disciplinary data visible and accessible to stakeholders for enhanced decision making through integrated storage, computational resources, and analytics support.
- Conduct interdisciplinary assessments of whole ecosystem function, services, and resilience that support product development and inform land stewards, government officials, and consumers.
- Working in partnership with conservation colleagues, develop and maintain metrics for landscape-scale data and knowledge for data-driven management of working lands.

Climate Research and Resiliency

Objectives:

- Synthesize climate research data and scientific information to inform data-driven and science-driven decision making and planning for agriculture, food, forestry and fuel production systems.
- Understand and convey knowledge about the influences of climate change and weather variability on agricultural, forest, and rangelands; stewardship systems and the communities built around them; as well as the products and societal benefits from our natural resources.
- Develop knowledge and tools to enable adaptation to climate change and weather variability, to improve the resilience of unmanaged and managed ecosystems and optimize the sustainability of agricultural management systems.
- Leverage economic analysis of land use and management, technology adoption and environmental program design to inform data-driven and science-driven decision making and planning.

Strategies:

- Create and contribute to research that addresses the resiliency and vulnerability of agricultural production, natural resource stewardship, and socioeconomic systems to climate change and weather variability.
- Generate peer-reviewed, science-based research and tools supporting data-driven decisions for agriculture, water resources, land, and forest management.
- Identify mechanisms to increase resilience of food and forest product systems after extreme events.
- Evaluate the environmental effects (benefits/limitations) of conservation practices selected for adaptation for climate change and weather variability or greenhouse gas mitigation. Use this evaluation for a spatially-explicit analysis of the economic costs and benefits from conservation practice implementation.
- Develop deeper knowledge of the human dimensions of climate change and weather variability, including perceptions and effective framing of risk, adaptation and mitigation incentives and the impact of climate change and weather variability on nutritional characteristics of food products.
- Examine the economic effects of climate change and weather variability on communities and agricultural producers to enable the development of appropriate/effective technologies.

Evidence building:

- Enhance soil-health metrics, with a focus not only on land for crop and animal production, but also forests, grasslands, and rangelands.
- Improve metrics from earth observations for identifying, measuring, and monitoring the effects of climate change and weather variability.
- Identify gaps in USDA observational networks (GRACenet, LTAR, FIA, EFRs) in which USDA is missing data and identify opportunities to utilize existing external datasets to fill these gaps.
- Assess the likely influences of climate change and weather variability on regional and global food, fuel, and forest security.

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