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Written Testimony for the hearing on  
“The Role of Climate Research in Supporting Agricultural Resiliency”  
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Chairman Scott, Ranking Member Thompson, and Members of the Committee, thank you for inviting me to speak to you today. My name is Sylvie Brouder, and I am an agro-ecologist and a Past President of the American Society of Agronomy (ASA). For the past 27 years, I have been a faculty member in the Department of Agronomy at Purdue University where I conduct research on cropping systems, their productivity and their impact on air and water quality. I am the Director of at Purdue’s Water Quality Field Station, a highly-instrumented, long-term research facility. My appointment also includes teaching and Cooperative Extension; the latter emphasizing development of nutrient management recommendations for farmers.

As leadership representing ASA, I speak today on behalf of the interests of our members and the members of our sister societies: the Crop Science Society of America (CSSA), and the Soil Science Society of America (SSSA). Collectively, the “Tri-Societies” represent more than 8,000 scientists in academia, Cooperative Extension, industry, and government, over 13,000 Certified Crop Advisers (CCA), and 620 Certified Professional Soil Scientists (CPSS). We are the largest coalition of professionals dedicated to the agronomy, crop, and soil science disciplines in the United States. Our members engage in the science that has documented agriculture’s contributions to climate change; they recognize agriculture’s opportunity to contribute to climate and food security solutions and they are dedicated to advancing the science of climate-smart agriculture and to rigorous translation of that science into evidence-based agricultural management recommendations. Our current strategic plans reflect this commitment in key strategies highly relevant to today’s hearing including pursuit of a common “Grand Challenge” of driving soil-plant-water-environment systems solutions for healthy people on a healthy planet in a rapidly changing climate as well as increased investment in “Knowledge to Action” and “Engagement, Inclusion, and Diversity.”<sup>1</sup>

### **Research and Data Infrastructure and Security Needs**

To accurately reflect our members’ perspectives in the national dialogue on research needs for agricultural resiliency, we conducted a survey of the potential for various management strategies to facilitate farmer adaptation to or mitigation of climate change. Respondents identified improvements in

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<sup>1</sup> The Strategic Plan for the American Society of Agronomy is available at <https://www.agronomy.org/files/Governance/strategic-plan-asa-2020-2023.pdf>

soil, water and nutrient management, and crop diversification and improvement as practices with highest potential with 45 to 60+ percent indicating more research was needed for a practice or suite of practices. These research needs are summarized in a statement we released last year on “*Advancing Resilient Agriculture: Recommendations to Address Climate Change*” where we highlight the potential ecosystem services that working lands can provide as well their complexities, synergies and trade-offs, and the challenges associated with their measurement and monitoring.<sup>2</sup> On-farm practice efficacy, including magnitude and timeline to impact, will be influenced by both the environment and the attributes of the farm enterprise itself. Thus, new crop, soil and agronomic science is needed to address site-specific nuances and as well as to keep pace with the changing weather patterns and the rapid evolution of on-farm technology and its implementation.

However, to achieve rapid and efficient gains in climate science for agricultural resiliency, we will need to address the significant impediment posed by a lack of data infrastructure long fostered by a research culture that has eschewed data sharing. In 2019, I led an analysis of the limitations to agricultural decision-making posed by a pervasive lack of accessibility and sharing of research data; for agriculture, the scope of data-related opportunities and challenges is hard to overstate. Historically, agricultural progress has been achieved through incremental aggregations of “small science,” hypothesis driven research conducted by individuals or small teams of researchers. The scientific reward and federal funding systems have co-evolved with this small science model ensuring persistence of this research culture. Yet, the small science approach cannot characterize the nuances and trade-offs that are hallmarks of grand challenge questions. Further, the historic culture of data disposal once a knowledge fragment is created can lead to distrust as an analysis cannot be reproduced and to inefficiencies because datasets from similar, small studies cannot be synthesized into larger, more nuanced analyses and cannot be reused to address new questions not originally envisioned when the data were collected.<sup>3</sup> Achieving free, open access to research data paves the way to equitable and inclusive solutions for the diverse array of US agricultural enterprises whose resiliency is now challenged by climate change.

For agriculture, organizing, standardizing and making publicly available non-sensitive raw data produced by small independent research studies is a critical first step to capitalizing on the opportunities and efficiencies afforded by the host of new “e-sciences” tools and technologies. Meta-analytical statistics can be applied to arrays of curated datasets from independent studies, an approach routinely used in medicine, education and other disciplines.<sup>4</sup> Results from such statistically powerful syntheses afford a more complete understanding of outcomes associated with a practice or intervention and provide a

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<sup>2</sup> Beyond food, feed and fiber, the ecosystem services that healthy agricultural systems can provide include air and water filtration, regulation of nutrient cycling, carbon sequestration and biodiversity promotion. Access *Advancing Resilient Agriculture* at <https://www.agronomy.org/files/science-policy/issues/2021-acsc-climate-solutions-statement.pdf>

<sup>3</sup> The full purpose of this analysis was to document the need for and anticipated benefits of developing data-sharing standards, incentivizing researchers to share data, and building a data-sharing infrastructure for agricultural research. For details, see Council for Agricultural Science and Technology (CAST). 2019. Enabling Open Source Data Networks in Public Agricultural Research. CAST Commentary QTA2019-1. CAST, Ames, Iowa.

<sup>4</sup> The Cochrane is a major resource for trusted evidence in medicine and is underpinned by meta-analyses. See <https://www.cochrane.org/>

robust translation of science into practice. With sufficient data, artificial intelligence is widely expected to offer new insights into agricultural resiliency. Large datasets created by harmonization of small datasets can be explored with methods such as machine learning to detect patterns and uncover important characteristics in aggregated data that are simply not present in the individual component datasets.

Data-sharing infrastructure, including easy-to-use workflows, would also accommodate research data not currently represented in peer-review publications. Highly regarded peer-review journals covering the agricultural sciences currently adhere to a litmus test of research “novelty” in order for a manuscript to be accepted. Thus, researchers commonly are unwilling or unable to invest the substantial effort needed to publish studies with confirmatory (e.g. studies that replicate results already in journal articles) or negative results.<sup>5</sup> Yet such studies are critical to the characterization of how impactful a management practice will be in the real world and to the development of an unbiased foundation to evidence-based practice. Making this “file drawer” or “dark” data available ensures public investments are not lost and can increase the reach of research results beyond a given region or beyond the original research question. It also ensures that syntheses across studies with meta-analysis are not biased by a preponderance of positive results in the published literature.

The quantity of data collected on farms by farmers and their technical service providers is increasing exponentially. Harnessing these data for development of management recommendations is widely considered an untapped opportunity to leverage public research investments. The simple notion that a farmer’s own data will both be useful in tailoring a recommendation to their farm and, when merged with research data, will strengthen and add needed nuance to recommendation frameworks currently motivates numerous projects. Much of my own ongoing research focusses on case studies to demonstrate the value of data sharing to spur development of agricultural data networks. At present, I lead a USDA NIFA-funded Coordinated Innovation Network to develop a cyber-infrastructure framework for integrating public and private data for evidence-based fertilizer recommendations.<sup>6</sup> Moving forward, most agricultural scientists now envision that implementation of data-driven decisions for climate smart agriculture requires interoperable public-private data networks that feed on-farm data back into decision-support tools to assist farmers in choosing which practices will have the most significant effect on their land.<sup>2</sup>

### **Realizing Data Infrastructure Requires Partnerships, Investment and Trust**

Designing a singular solution for agricultural data seems inherently untenable given a large array of networks and repository initiatives that are emerging to address infrastructure needs. In recent years,

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<sup>5</sup> It is common practice for Extension Specialists to conduct experiments to confirm the effectiveness of a new agricultural management practice in their state or region. Results from these field trials are used in local education programs but may never be formally published in a journal article and results are commonly not preserved or curated for future use.

<sup>6</sup> USDA’s National Institute for Food and Agriculture (NIFA) – Agriculture and Food Research Initiative is a major funding source for Tri-Societies’ members research on management practices that influence agriculture’s resiliency to climate change. The Data Science for Food and Agriculture Systems Program funds my on-going cyber-framework project.

federal agencies including USDA have instituted programs and policies to drive data sharing and reap its benefits. Funding requests by researchers must now be accompanied by a data management plan that details handling of data generated by projects during and after the completion of the project including details on how the data will be produced or acquired, managed, stored, shared, and protected.<sup>7</sup> The general expectation is that all data will be preserved and curated in a form that is reusable (i.e. contains enough information and annotation for independent understanding). In the case of NIFA-funded projects, researchers are encouraged but not required to deposit data in USDA's Ag Data Commons.<sup>8</sup> However, most researchers have numerous options for data preservation including domain-specific databases<sup>9</sup>, general purpose publishing repositories, and institutional research repositories.<sup>10</sup> Many of these repositories provide curation and preservation and make data available for free but may be tailored to specific needs of their immediate stakeholders. They have potential to contribute to a data infrastructure solution for agriculture but at present they are not well coordinated and most do not yet have strong business models to ensure sustainability. Additionally, they use a variety of approaches to describing data.

The key to ensuring data are interoperable across datasets, networks, and repositories is the creation of and adherence to common metadata and data standards.<sup>3</sup> Such standards are currently under development but more engagement in standards development by researchers and their professional societies is needed. At ASA, leadership has been gleaned lessons-learned by other societies as they pursue development of standards for their membership.<sup>11</sup> For agriculture, the development of data standards and their broad adoption by existing infrastructures can be expected to remain a challenge in the foreseeable future and should be a high priority in the climate resiliency agenda. Ultimately, designing functional data architecture for agriculture requires partners in the research data value chain (e.g. researchers, their institutions and sponsors, etc.) to commit to collaborative and iterative analysis of successes and failures in design and utility.

Competitive grants programs including NIFA can and have supported the development of new data architecture, tools and apps but these short-duration funds target innovation and are not currently positioned to finance long-term maintenance of databases and other data infrastructure. The cost of data infrastructure for agriculture is currently unknown. Databases with longevity almost always have

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<sup>7</sup> For the guidance on Data Management Plans for NIFA-funded projects see <https://www.nifa.usda.gov/data-management-plan-nifa-funded-research-education-extension-projects>

<sup>8</sup> USDA's National Agricultural Library created the Ag Data Commons is a data catalog and repository available to help the agricultural research community share and discover research data funded by USDA and meet Federal open access requirements.

<sup>9</sup> Domain data repositories are designed to house data of similar focus. An example is SoyBase, the USDA's soybean genetics database. See [https://www.soybase.org/sb\\_about.php](https://www.soybase.org/sb_about.php)

<sup>10</sup> An example of an institutional repository is the Purdue University Research Repository where any researcher with a Purdue affiliation can formally publish a dataset from any research domain. It was developed to meet the data management planning requirements of Federal funding agencies and currently houses 1300+ publicly available datasets, many in the agricultural domain. <https://purr.purdue.edu/>

<sup>11</sup> The Council of Scientific Society Presidents (<https://www.sciencepresidents.org/>) recently facilitated a year-long series of presentations and discussions on Data Sharing

core, institutional support.<sup>12</sup> Delivering data online for free – in keeping with goals of democratized access to publicly funded research – requires workflows and human resources for stewardship that will drive costs well beyond those needed for storage. One option is for public and private funding organizations to pay directly for stewardship in contributions that are proportional to the size of a grant.<sup>13</sup> In our analysis of data infrastructure needs<sup>3</sup>, we propose the USDA Research Education and Economics office provide leadership and oversight to piloting agricultural case studies exploring potential business models. The Agriculture Advanced Research and Development Authority (AgARDA) created by the 2018 Farm Bill was envisioned to have the authority and investment needed to facilitate sharing of research data. Full appropriation of authorized funds would position AgARDA to lead a partnership of agricultural data stakeholders in the development and implementation of data infrastructure.

Without question, there are a host of additional data-related issues that must be addressed when considering access and use of private data including the farmer-owned and on-farm data that is anticipated to greatly benefit the science of agricultural resiliency to climate change. For farmers, the marginal cost of data storage is low but the up-front costs to collect and manage these data can be expensive. These costs must be fully recognized when researchers solicit their use. Further, there is a pervasive concern, even among collaborators within farmer networks, that their data will be used for regulatory and/or punitive purposes. For example, many states have regulations pertaining to non-point sources of nutrients that exacerbate farmer unwillingness to share key management details needed for reuse of their data. However, numerous mechanisms already exist for data anonymization and other sectors have clearly demonstrated that private and personal data can be secured and used without risk to the individual. Medicine relies heavily on individual patient data to characterize the efficacy of clinical practices and has largely been successful in securing individual identity and developing trust through an array of personal protection legal instruments. Borrowing these strategies from a high-stakes sector like medicine would be a natural starting place for building farmer trust and willingness to engage.

### **Developing a Diversified Workforce for Climate Smart Agriculture**

In our Strategic Plan, ASA's focus on "Knowledge to Action"<sup>1</sup> reflects our commitment to our CCA membership and recognizes that access to recommendations that align with and are transparent to the underpinning science is a major barrier to continually advancing agricultural sustainability and resiliency at scale. While there are significant knowledge gaps that require more research, there is already a large volume of existing scientific research on practices and their impacts on productivity and environmental outcomes. For example, numerous practices have been extensively studied for their ability to sequester carbon (C) in soil for climate change mitigation and/or to reduce soil C losses commonly associated with agricultural activities – critical to both climate mitigation and adaptation and a central tenant for

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<sup>12</sup> Attwood, TK, B Agit, LB Ellis, 2015. Longevity of biological databases. *EMBnet.journal* 21.e803. <https://journal.embnet.org/index.php/embnetjournal/article/view/803/1209>

<sup>13</sup> Gabella, C, C Durinx, R Appel. 2017. Funding Knowledgebases: Towards a sustainable funding model for the UniProt use case. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5747334/>

regenerative agriculture. Yet practice adoption at scale remains low reflecting a dearth of science-based educational materials and human resources to facilitate technology transfer.

The C markets are currently targeting payments for practices that may require implementation of a decade or more for measurable change to occur, and farmers are understandably concerned about payment levels offered and legal liabilities associated with non-compliance.<sup>14</sup> Indeed, as revealed by our member survey, other practices for “4 R” nutrient management,<sup>15</sup> on-farm energy efficiencies, etc. may offer an as or more realizable approach to achieving on-farm climate mitigation even though soil C sequestration is a cornerstone for climate adaptation. For practice adoption to occur at scale, there is an urgent need for new education materials that accurately characterize potential benefits, including timelines to and magnitudes of measurable benefit and certainty of benefit realization for a particular purpose (e.g. greenhouse gas emission mitigation, soil moisture conservation and adaptation to increased precipitation uncertainty).

The need to bolster capacity for technology transfer is widely recognized throughout the public and private sectors. Joint Policy Recommendations from the Food and Agriculture Climate Alliance highlight enhancing access to technical assistance to ensure producers can overcome barriers to the practices that can lead to improvements in soil health and reduce greenhouse gas emissions.<sup>16</sup> In 2020, the eXtension Foundation published an analysis of existing Cooperative Extension programs on climate and extreme weather and highlighted the urgent need for unified, nationally coordinated programming that wholistically addresses climate adaption and mitigation.<sup>17</sup> Of particular note was the current dearth of programs to address the needs of minority communities. Our Tri-Society statement *Advancing Resilient Agriculture*<sup>2</sup> also highlights the need for educational programs that are more directly responsive to on-farm realities, especially with respect to the confusing array of emerging carbon and ecosystem service markets.

NIFA currently has an open call for one competitively-funded Coordinated Agricultural Project to support farmers, ranchers and foresters in implementing climate-smart and nature-based solutions.<sup>18</sup> However, the current investment level is too low to achieve a sustained, increased capacity in climate-smart programming. In keeping with our commitment to our Grand Challenge, the Tri-Societies are currently seeking partners to assist in climate smart and food security capacity development. Last December, we collectively committed to investing \$500,000 of our internal funds to building a new

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<sup>14</sup> For a recent Purdue Univ. analysis of Opportunities and Challenges Associated with “Carbon Farming” see [https://ag.purdue.edu/commercialag/home/wp-content/uploads/2021/06/202106\\_Thompson\\_CarbonMarkets.pdf](https://ag.purdue.edu/commercialag/home/wp-content/uploads/2021/06/202106_Thompson_CarbonMarkets.pdf)

<sup>15</sup> 4R Nutrient Management focuses on apply the right rate and source of fertilizer in the right place and at the right time.

<sup>16</sup> The Food and Agriculture Climate Alliance is coalition of organizations representing farmers, ranchers, forest owners, the food sector and environmental advocates working to define and promote shared climate policy priorities. For their Joint Policy Recommendations, see <https://agclimatealliance.com/>

<sup>17</sup> Extension Climate and Extreme Weather Programming. 2020. <https://online.flippingbook.com/view/310442/Xtension> Foundation

<sup>18</sup> This NIFA funding opportunity is in the Crosscutting Priority Area. The Program Area is Extension, Education, & USDA Climate Hubs Partnership and offers one \$10M, 5-year award.

Carbon and Ecosystem Services Education Project, “Decode Six.”<sup>19</sup> The first priority of this program is to provide trusted educational resources to address the confusion occurring on farms regarding the proliferation of carbon and ecosystem service markets. We are building a science-based, unbiased, open access website featuring materials from peer-reviewed science. For content, we are drawing on the expertise of our members and the science community writ large. Relevance and content inclusivity will be achieved through engagement of our CCAs and external partners including the Ecosystem Service Market Consortium<sup>20</sup> and their Producer’s Circle and their Working Group on Inclusion and Racial Justice. Our programming will also be informed by the Tri-societies’ renewed commitment to diversity, equity and inclusivity. We envision a scientific community where every person, regardless of their background and challenges, is able to achieve their professional potential; a vision accelerated by open access to both our science and data resources.<sup>21</sup> Our goal is to grow both our educational platform and the diversity of the membership we represent via partnerships. To that end, I represent the Tri-Societies on the Climate Priority Action Team of Extension Committee on Organization and Policy (ECOP). The Action Team seeks to build resource for climate Extension programs via partnerships with federal government agencies, non-profits and philanthropic organizations.

Finally, advancing data-driven solutions in agriculture also requires new formal curricula at the undergraduate and graduate levels that ensures students gain some understanding of data sciences and their use in agricultural and food systems research. Current demand in the agricultural sector for students skilled in data and computational sciences is far outstripping supply. Indeed, the major, regional crop consultancy group that collaborates on my NIFA-funded cyber-framework project<sup>6</sup> employs agronomists and data/computer scientists at roughly equivalent rates. While not every student of agricultural sciences will need to be a “data scientist,” they will all need some understanding of basic principles, data tools and ethics. Next generation Extension Specialists require curricula on core methodologies for assessing data validity, data wrangling, the transparent and unbiased synthesis of studies and communicating scientific uncertainty. As forecast for the general workforce,<sup>22</sup> agriculture will need individuals with appropriate domain knowledge but also individuals with the mathematical, computational and statistical skills to help manage and use the volume of data generated by research and on-farm monitoring networks. Reorienting traditional curricula to encompass data sciences creates the ancillary opportunity of recruiting a host of non-traditionally oriented students into agriculture, a key to diversification of the agricultural workforce.

Thank you for the opportunity to testify before this panel. I would be glad to address your questions and I look forward to the discussion.

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<sup>19</sup> “Decode Six” is in reference to decoding carbon, which has an atomic number of six on the Periodic Table of Elements.

<sup>20</sup> The Ecosystem Services Market Consortium is a non-profit, member-based organization dedicated to advancing ecosystem service markets. See <https://ecosystemservicesmarket.org/>

<sup>21</sup> Our Tri-Society DEI statement can be accessed at <https://www.agronomy.org/files/DEI/acs-dei-statement-2021.pdf>

<sup>22</sup> The Business Higher Education Forum. 2017. Investing in America’s Data Science and Analytics Talent: The Case for Action. [https://www.bhef.com/sites/default/files/bhef\\_2017\\_investing\\_in\\_dsa.pdf](https://www.bhef.com/sites/default/files/bhef_2017_investing_in_dsa.pdf)