August 1, 2020

Stephen Censky
Deputy Secretary
U.S. Department of Agriculture
Washington, DC 20250

Re: Solicitation of Input From Stakeholders on Agricultural Innovations, USDA–2020–0003 (Fed. Reg. Vol. 85, No. 63, Apr. 1, 2020, page 18185)

Dear Deputy Secretary,

The National Sustainable Agriculture Coalition (NSAC) welcomes the opportunity to submit recommendations to the U.S. Department of Agriculture's (USDA) Agricultural Innovations Agenda. NSAC is a national alliance of over 130 family farm, rural, and conservation organizations that together take common positions on federal agriculture, food policies, and agriculture research to advance sustainable agriculture, including the 48 represented member organizations[i] listed at the end of this letter.

We were heartened to see systems-based farm management on the Department's list of four clusters with the potential to facilitate transformative breakthroughs to enable U.S. agriculture to reduce its environmental footprint while improving productivity. In our considered view, the systems-based farm management cluster is the most important cluster on which to focus. Systems-based farm management strategies are critical to provide farmers with the necessary tools to increase sustainability, productivity, and become more resilient to a changing climate.

Farmers and ranchers are on the frontlines of the climate crisis, and there is no doubt that agriculture will face future challenges as a result of rising average temperatures and increasingly erratic fluctuations in growing seasons, temperature extremes, rainfall patterns, and pest and disease pressures. NSAC's 2019 publication, *Agriculture and Climate Change: Policy Imperatives and Opportunities to Help Producers Meet the Challenge*,[1] outlines the need for expansive research to help U.S. agriculture systems adapt and maintain economic, ecological, and community health as the climate crisis becomes more extreme. The research findings and policy recommendations in the publication align with the systems-based farm management innovation cluster, outlining the steps that Congress and

[1] *Agriculture and Climate Change: Policy Imperatives and Opportunities to Help Producers Meet the Challenge*. Washington D.C. https://sustainableagriculture.net/wp- content/uploads/2019/11/NSAC-Climate-Change-Policy-Position_paper-112019_WEB.pdf

USDA must take to optimize agricultural production and resilience while greatly reducing the environmental footprint of U.S. agriculture, including achieving a climate-neutral or climate positive (net carbon sequestration) impact by 2050.

The research outcomes and innovations from the systems-based farm management cluster are the most likely to be applicable by farms and ranches of all sizes. Innovations from the other three clusters – genome design, digital/automation, and prescriptive intervention – will need an explicit set of research criteria to ensure the research outcomes will not be geared toward the largest and wealthiest agricultural operations, and thus further contributing to concentration and lack of operation diversity in American agriculture. Such outcomes would run counter to the public interest and the mission of USDA's Research, Education, and Economics (REE) mission area to create economic opportunity in farming and rural communities. It would also run against the United States policy "to foster and encourage the family farm system of agriculture in this country" and the "express intent of Congress that no such program be administered in a manner that will place the family farm operation at an unfair economic disadvantage" *(7 U.S.C. 2266*). Farmers within our coalition are especially concerned that the first three clusters show a disconnect between USDA's research priority areas and the actual needs of farmers and ranchers.

Systems-based farm management plays an invaluable role in supporting adoption of conservation activities and climate-friendly farming systems. NSAC's goal is to equip farmers and ranchers with the tools they need to meet the challenges of the climate crisis head-on, while increasing productivity and profitability. It's imperative that USDA concentrate on supporting systems that meet the needs of U.S. consumers for high-quality food, help farmers maintain resilient and profitable operations, and protect the health of our shared natural resources. We appreciate your serious consideration of our recommendations and would welcome the opportunity to discuss further.

Sincerely,

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Senior Strategic Advisor

Cristel Zoebisch
Climate Policy Associate

cc:
Dr. Scott Hutchins, Deputy Under Secretary, Research, Education, and Economics
Dr. Chavonda Jacobs-Young, Administrator, Agricultural Research Service
Dr. Parag Chitnis, Acting Director, National Institute of Food and Agriculture
Dr. John Dyer, Research Leader and Research Molecular Biologist

[i] Agriculture and Land-Based Training Association Salinas, CA; Alternative Energy Resources Organization Helena, MT; CCOF Santa Cruz, CA; CalCAN Sacramento, CA; California FarmLink Santa Cruz, CA; C.A.S.A. del Llano (Communities Assuring a Sustainable Agriculture) Hereford, TX; Catholic Rural Life St Paul, MN; Center for a Liveable Future – John Hopkins University Baltimore, MD; Center for Rural Affairs Lyons, NE; Clagett Farm/Chesapeake Bay Foundation Upper Marlboro, MD; Community Alliance with Family Farmers Davis, CA; Community Involved in Sustaining Agriculture South Deerfield, MA; Dakota Rural Action Brookings, SD; Delta Land and Community, Inc. Almyra, AR; Ecological Farming Association Soquel, CA; Farmer-Veteran Coalition Davis, CA; Florida Organic Growers Gainesville, FL; FoodCorps, OR; GrassWorks New Holstein, WI; Hmong National Development, Inc. St Paul, MN and Washington, DC; Illinois Stewardship Alliance Springfield, IL; Institute for Agriculture and Trade Policy Minneapolis, MN; Interfaith Sustainable Food Collaborative Sebastopol, CA; Iowa Natural Heritage Foundation Des Moines, IA; Izaak Walton League of America St. Paul, MN/Gaithersburg, MD; Kansas Rural Center Topeka, KS; The Kerr Center for Sustainable Agriculture Poteau, OK; Land Stewardship Project Minneapolis, MN; MAFO St Cloud, MN; Maine Farmland Trust Portland, ME; Michael Fields Agricultural Institute East Troy, WI; Michigan Food & Farming Systems – MIFFS East Lansing, MI; Michigan Organic Food and Farm Alliance Lansing, MI; Midwest Organic and Sustainable Education Service Spring Valley, WI; Montana Organic Association Eureka, MT; The National Center for Appropriate Technology Butte, MT; National Center for Frontier Communities Silver City, NM; National Hmong American Farmers Fresno, CA; Nebraska Sustainable Agriculture Society Ceresco, NE; Northeast Organic Dairy Producers Alliance Deerfield, MA; Northern Plains Sustainable Agriculture Society LaMoure, ND; Northwest Center for Alternatives to Pesticides Eugene, OR; Ohio Ecological Food & Farm Association Columbus, OH; Oregon Tilth Corvallis, OR; Organic Farming Research Foundation Santa Cruz, CA; Organic Seed Alliance Port Townsend, WA; Pesticide Action Network Berkeley, CA; Rural Advancement Foundation International – USA Pittsboro, NC; Union of Concerned Scientists Food and Environment Program Cambridge, MA; Virginia Association for Biological Farming Lexington, VA; Wild Farm Alliance Watsonville, CA; Women, Food, and Agriculture Network Ames, IA.

Recommendations on the Agricultural Innovation Agenda

1. Input from AIA Listening Session

NSAC collected input and feedback for our comment on the Agricultural Innovation Agenda via a listening session with farmers and ranchers within our network and by requesting input from our coalition members. The listening session was held on June 30, 2020, and was attended by 186 participants, including 40 farmers and ranchers, 18 conservationists, 17 Extension agents, 29 researchers, and 82 participants self-identified as "other" professionals. USDA staff also attended the listening session, which was held online. Participants had the opportunity to comment verbally, participate in online polls during the session, write comments into the chat box function, and provide additional input via a post-event evaluation form.

Farmers and ranchers identified the climate crisis as the biggest challenge that they face as they seek to optimize productivity and resilience, strengthen economic viability, and decrease negative environmental impacts over the next 10 to 30 years. Farmer and rancher participants expressed concerns with ever increasing unpredictability of weather events and concerns around building climate resilience into their operations. Farmers highlighted the need for innovations to build resilience and help combat climate change, including crop and livestock breeding and public cultivar and breed development for organic and agroecological systems, and for resilience to weather extremes, diseases, and other stresses. Other challenges raised by farmers and ranchers included lack of processing infrastructure and limited access to meat processors for small and very small growers, access to capital and land, unfair competition, and uneven enforcement of organic regulations and standards.

Farmers and ranchers identified the following as the biggest opportunity areas for innovation:

- transitioning conventional agriculture to sustainable, organic, and other climate resilient production systems;
- investments in regionally adapted and climate-resilient plant and animal breeding;
- research and demonstrations of farming practices that build soil health and sequester carbon;
- taking a systems approach to the continuum of soil, plant, animal, and human health, seeking to maximize nutritional value per acre and not simply yield per acre; and
- increasing access and support for local and regional food systems.

Farmer participants also emphasized the importance of leveling the playing field for small and mid-scale farmers and the need to center innovations and research around the articulated real-world needs of farmers. Farmer and rancher participants highlighted the social aspects of sustainability, including supporting local economies, racial and social equity, and decent pay and working conditions for farmworkers and food system workers. There was a strong interest from participants on quality of life and farming providing a viable living for producers.

Researcher participants expressed eagerness to conduct systems-level, applied research that is relevant to farmers and ranchers, but noted that the other three "innovation clusters" (genome design, digital/automation, and prescriptive intervention) may not address the needs of many producers. The disconnect between USDA's research priority areas and the actual needs of farmers and ranchers, they said, needs to be addressed explicitly in the innovation agenda.

Overall, the vast majority of listening session participants found the Systems Based Farm Management innovation cluster area highly relevant and expressed less enthusiasm and some dissatisfaction with the other three innovation clusters. This sentiment was consistent throughout the oral comments and was also reflected in the polls administered during the listening session, which showed:

- An overwhelming majority of farmers and other stakeholders rated Systems-Based Farm Management as highly relevant.
- Less than half of farmer participants found Genome Design relevant, and only a third anticipated benefits to their livelihoods from this technology.
- A little more than half of farmer participants found the Prescriptive Intervention/Data Management relevant, while only a minority considered the Digital/Automation and field sensing technology relevant.

Some key points made in the listening session include:

- Future innovation should emphasize agroecological and organic approaches that minimize dependence on synthetic fertilizers and crop protection chemicals.
- Soil health innovations should be more prominent and include optimizing plant-soil microbiome function and practices for carbon sequestration, water quality, and resilience to drought, flooding and other extreme weather events.
- Water use efficiency and water quality protection emerged as major priorities.
- New technologies should be relevant and accessible to small and medium-sized, diversified operations, and should support rural community wellbeing and prosperity.
- New technologies should be thoroughly vetted and controlled to avoid negative unintended consequences, both ecological (e.g. impacts of gene-edited organisms on agroecosystem function) and social (e.g., technologies that further promote consolidation resulting in loss of jobs and economic opportunity).
- Livestock innovations should prioritize advanced grazing management, systems serving local/regional markets, and livestock breeding for climate and stress resilience, disease resistance, and organic systems.
- Innovations should embrace social considerations, including racial equity, establishing the next generation of farmers, human health outcomes (optimize nutritional value per acre), and

integration of urban and nearby rural communities, and farming and non-farming populations.

During the listening session, participants were asked to answer two poll questions regarding **systems-based farm management**. Below are the results of the polls:

Poll Question	Overall Results	Farmer Results
1) Is this priority relevant to your operation/research?	93% Agree 7% Disagree	96% Agree 4% Disagree
2) Would outcomes from these broad innovations improve your future livelihood? Why or why not?	94% Agree 6% Disagree	96% Agree 4% Disagree

Systems-based farm management was by far the most relevant innovation cluster for all participants of the listening session, including farmers and ranchers.

During the listening session, participants were asked to answer two poll questions regarding **genome design**. Below are the results of the polls:

Poll Question	Overall Results	Farmer Results
1) Is this priority relevant to your operation/research?	60% Disagree 40% Agree	54% Disagree 46% Agree
2) Would outcomes from these broad innovations improve your future livelihood? Why or why not?	65% Disagree 35% Agree	67% Disagree 33% Agree

Less than half of farmer participants found Genome Design relevant, and only a third anticipated benefits to their livelihoods from this technology. However, farmers expressed deep concern about climate disruption and the need for innovations to build resilience and help combat climate change, including crop and livestock breeding and public cultivar/breed development for agroecological systems, including organic systems, and for resilience to weather extremes, diseases, and other stresses. Thus, depending on how crop and livestock genetic improvement is framed, we would conclude that interest level could be high or very low.

During the listening session, participants were asked to answer two poll questions regarding **digital/automation and field sensing technology**. Below are the results of the polls:

Poll Question	Overall Results	Farmer Results
1) Is this priority relevant to your operation/research?	51% Disagree 49% Agree	76% Disagree 24% Agree
2) Would outcomes from these broad innovations improve your future livelihood? Why or why not?	51% Disagree 49% Agree	55% Disagree 45% Agree

Several farmer and rancher participants expressed that innovations from the digital/automation cluster would not be the most helpful innovations for them since they would not be able to use them due to non-availability or low-availability of broadband or satellite access, concerns that innovations would be targeted to large-scale operations, and apprehension that greater technological advances would result in greater concentration in agriculture.

A farmer participant commented, "many of those priorities outlined [by USDA] did not feel relevant to where I see myself in the next 10-20 years, because they focused on large operation issues."

Another participant shared concerns regarding ownership and control of these technologies to avoid greater consolidation in agriculture. Various participants emphasized the need for scale-appropriate technology, citing that small and mid-scale farmers in Europe and Asia have many more technology tools available to them than American farmers.

During the listening session, participants were asked to answer two poll questions regarding **prescriptive intervention, data management, and software tools**. Below are the results of the polls:

Poll Question	Overall Results	Farmer Results
1) Is this priority relevant to your operation/research?	61% Agree 39% Disagree	56% Agree 44% Disagree
2) Would outcomes from these broad innovations improve your future livelihood? Why or why not?	67% Agree 33% Disagree	64% Agree 36% Disagree

2. NSAC Recommendations

A. Optimize Production Based on Nutrition and Sustainability Goals

NSAC strongly recommends that USDA reframe the agricultural production goal of the Agricultural Innovation Agenda to **optimize** U.S. production to meet current and future nutritional needs while reaching net zero greenhouse gas emissions from agriculture and reducing other negative environmental impacts using the best available sustainable systems and practices. The goal of increasing agricultural productivity by 40 percent by 2050 is actually more of a means than an end and should be backstopped by the actual goal or purpose for such an increase, namely meeting nutritional needs. By making the primary goal to increase productivity, the innovation agenda suffers from lack of clarity as to why such an increase is needed. We are concerned that emphasis on increasing productivity might perpetuate overproduction, low farm prices, unsustainable and unhealthful diets, an overreliance on export markets, and extreme food waste. Alternatively, can we optimize production and farming system diversity to achieve a more desirable outcome of sustainable diets, low food waste, and balanced supply and demand? As one farmer participant shared during the listening session, "we are raising good food to nourish people, not commodities. The 'commodities' focus has driven half of my neighbors out of business and harmed our communities."

U.S. agriculture could serve as a model for other countries of long-term sustainability, land stewardship, and quality nutrition, informed by systems thinking and coordinated to ensure an equitable, healthful, sustainable, and resilient food supply for all U.S. residents and future generations. As our own agricultural system evolves toward true long term sustainability through application of research into soil health, nutrient cycling, crop diversity, crop and livestock genetic improvement, crop-livestock integration, climate mitigation and resilience, and other ecosystem services, our research outcomes could potentially help other nations develop sustainable agricultural and food systems adapted to their locales and cultural needs and traditions.

B. Keep Soil Health, Sustainability, and Agricultural Resilience Front and Center

Missing from the Agricultural Innovation Agenda is a clear goal related to the most pressing issue facing agriculture, namely the climate crisis. We urge USDA to add as an explicit goal of reaching net zero greenhouse gas emissions from U.S. agriculture in the shortest amount of time feasible. This is not necessarily captured by the goal of reducing the environmental footprint of U.S. agriculture in half by 2050. We recommend revised language stating "…while reaching net zero greenhouse gas emissions and reducing by at least half the other environmental impacts of U.S. agriculture by 2050."

The 2019 National Academies of Sciences, Engineering, and Medicine (NAS) report, *Science Breakthroughs to Advance Food and Agricultural Research by 2030*, that informed the innovation clusters for the Agricultural Innovation Agenda framed advanced technology solutions and big data as supporting tools to build soil health, water and nutrient use efficiency, agricultural resilience, and long-term sustainability throughout the agricultural and food system. However, the request for stakeholder input removed the emphasis on soil health, sustainability, and resilience in the NAS report. NSAC encourages USDA to review comment submissions with an emphasis on how these innovations serve these larger goals, as intended in the NAS report.

Several research gaps exist regarding agriculture's role in mitigating the climate crisis. In addition to adding the explicit goal of reaching net zero greenhouse gas emissions from U.S. agriculture as soon as possible, USDA should include the following research gaps in the Agricultural Innovation Agenda as key topics that need to be addressed:

- The need for better tools to measure soil carbon sequestration;
- Advanced nutrient management for mitigation of nitrous oxide emissions;
- Integrated soil health management strategies for annual and perennial cropland, grazing lands, and whole farm ecosystems to promote long term sustainable production, agricultural resilience, and carbon sequestration; and
- Improved life-cycle analyses of livestock production systems to accurately quantify climate impacts of concentrated animal feeding operation (CAFO) based and pasture-based production systems.

C. Re-Insert the Fifth Cluster – the Microbiome

The NAS report listed a fifth Breakthrough category or cluster: increasing our understanding of animal, soil, and plant microbiomes and their broader applications across the food system. It is unclear why USDA listed only four clusters, leaving out this important fifth cluster from the NAS report. We strongly urge adding this fifth cluster to the Agriculture Innovation Agenda.

We also note that the NAS report listed systems-based farm management first. We urge the Department to also give it first priority, followed by the microbiome, before then turning to genomics, digital/automation/precision agriculture and prescriptive intervention/data collection and analysis.

D. Incorporate the Social Dimensions of Sustainability in All Clusters

Future innovation must incorporate social considerations, including racial equity, farming opportunity and viability, supporting the next generation of farmers, widespread ownership of farmland, secure tenure, rural community health and wellbeing, human health outcomes, farmworker health and safety, and overall quality of life. New technologies should be relevant and accessible to small and medium-sized, diversified operations, and should support community wellbeing and prosperity. These technologies should be thoroughly vetted and controlled to avoid negative unintended consequences, both ecological (e.g. impacts of gene-edited organisms on agroecosystem function) and social (e.g., technologies that further promote consolidation resulting in loss of jobs and economic opportunity).

E. Include Advanced Grazing as a Priority for Systems-Based Farm Management

We recommend that the Agricultural Innovation Agenda invest in transdisciplinary investigation and development of regionally appropriate advanced grazing management systems to facilitate widespread adoption and to further document their benefits to soil, forage, and livestock health; climate mitigation and resilience; meat quality and human nutrition; and social benefits including but not limited to air quality and drinking water safety.

Challenges related to current livestock production systems range from manure management, livestock disease and stress, water and air quality impacts, and greenhouse gas emissions (GHG) of large CAFOs, to poor production, low yield-to-GHG ratios, and significant declines in soil carbon and soil health in grazing systems that not optimally managed.

In contrast, management intensive grazing (MIG) and other advanced grazing management systems adapted to locale have been shown (in multiple studies across the country from GA, NY, ND, TX, and elsewhere) to restore soil and forage health, improve livestock health and production, and sequester a ton or more of carbon per acre annually. For example, rancher and author Gabe Brown restored 5,000 acres of depleted rangeland in North Dakota, increasing soil organic matter from 2 percent to 7 percent over a 20-year period, allowing these fields and range to sustain crop and livestock yields through droughts that caused production failures on neighboring farms.[1] A tremendous opportunity exists for transdisciplinary research to help livestock producers transition their operations to the best MIG or advanced grazing management for their locales, climates, soils, and markets.

The outcomes of widespread adaptation and implementation of advanced adaptive grazing systems for livestock production across the U.S. include groundwater and surface water protection and safer drinking water, soil conservation and soil health, carbon sequestration and a much lower net GHG footprint for livestock production, improved production and resilience, better quality of life for ranchers, improved livestock wellbeing and thus greater consumer appeal, and more healthful meat, dairy, and eggs for consumers. Given the solid and widespread evidence of the success of MIG and related systems, including numerous rancher success stories, the leading hurdles to more widespread adoption likely include initial costs of infrastructure (e.g. fencing and water facilities for multiple paddocks), acquiring new management skills, lack of educational and technical assistance resources, and other socioeconomic factors that deter adoption. Research needs to include improved livestock

[1] Brown, G. 2018. *Dirt to Soil: One Family's Journey into Regenerative Agriculture*. White River Junction, VT: Chelsea Green Publishing

genetics for MIG and grazing-based systems, regionally adapted forage mixes for MIG systems, and adaptation of MIG principles to locale, soil, climate, livestock species, production scale, and market strategy.

F. Include Agrivoltaics Research within the Systems-Based Farm Management Cluster

As solar installations increase on U.S. farmland, concerns have arisen that "big solar" installations have covered thousands of acres of prime farmland, thus foreclosing not only food production but also the carbon sequestration and other ecosystem services of fertile soil. A more sustainable approach to on-farm solar (or agrivoltaics) is to integrate smaller, decentralized solar operations into agricultural production to provide renewable energy to the farms themselves and nearby communities. Research into dual land uses is needed to develop integrated strategies in which agricultural crops and solar panels share the same tract of land and mitigate land competition between crop production and commercial-scale solar panel deployment. We recommend this research be pursued with a sense of urgency to help farmers navigate these mostly uncharted waters and to help uncover and foster win-win scenarios for the energy and agriculture sectors involved.

G. Include a Heightened Focus on Organic Production Systems as a Systems-Based Farm Management Cluster Priority

We recommend an explicit and strong focus on organic production systems within the systems-based farm management cluster, for both crop and livestock production, with particular attention to soil health, system resilience, and climate adaptation and mitigation.

This research topic applies to USDA certified organic, transitioning-organic, exempt-organic, and other NGO-certified farmers and ranchers. It applies to all agricultural commodities. In addition, much of this research will benefit non-organic producers as well, empowering them to attain their production, resilience, and ecosystem services goals.

Organic production systems merit systems research, including development of crop cultivars and livestock breeds suited to organic systems; integrated soil health management systems (cover crops, diversified rotations, reduced tillage, organic amendments, etc.); climate mitigation and climate resilience (yield stability, resource conservation); and optimization of soil, plant, and animal microbiomes and plant-microbe partnerships for crop production and vigor, nutrient and water efficiency, and soil health, water quality, carbon sequestration, and other ecosystem services.

The organic approach offers unique opportunities to help U.S. agriculture meet the goals of halving the environmental footprint while sustaining quantity and quality of production through climate change and other stresses and disruptions. Organic systems include:

- building healthy living soils as a foundational principle and practice;
- avoidance of synthetic fertilizers and crop protection chemicals thereby protecting soil biota and other resources; and
- more diversified production systems that better sustain ecosystem health, reduce pest and disease pressures, enhance the economic viability and stability of farming and ranching operations, and provide a more diverse and healthful diet for consumers.

Challenges related to organic production include:

- A lack of crop cultivars and livestock breeds adapted to organic systems;
- A historical underfunding of research and extension for organic systems;
- The need to reduce the intensity of tillage practices, noting that great progress has been made and continues to be made in conservation tillage practices for organic systems;
- A tendency for organic nutrient sources to provide excessive amounts of phosphorus (which can set back efforts to optimize soil biota and soil health);
- Difficulties in providing sufficient nitrogen for crop production especially in the early years after transition into organic systems; and
- Unique pest, weed, and disease management challenges.

Although USDA research investments in organic agriculture have increased significantly in the past 18 years, the percentage of USDA research dollars devoted to organic systems (less than 2%) still lags far behind the market share for organic foods (approaching 6%). Given the potential for organic systems to enhance soil health, agricultural resilience, and yield stability, evidenced by recent research indicating the carbon sequestration and climate mitigation potential of best organic practices and systems, and findings that synthetic agrochemical inputs can also damage soil biota, a strong rationale – even an imperative – exists for a more significant USDA investment of research dollars into enhancing the capacity of organic production systems to meet production and environmental goals of the Agricultural Innovation Agenda.

Finally, organic foods have lower pesticide residues, sometimes better nutritional value, and hence stronger consumer appeal and demand (which currently exceeds USDA certified organic production of many commodities). While USDA organic standards exclude the use of genetically modified organisms and synthetic materials, nature's "library" of existing soil, plant, and animal microbiomes, plus existing non-GMO crop and livestock germplasm are sufficient to support major advances in crop genetics and microbiome management for organic production.

Outcomes of organic systems research include both more widespread adoption of organic practices and associated environmental and soil benefits, and improvement of those practices to better meet soil health, nutrient cycling, and environmental goals as well as production objectives. Development of public crop cultivars and livestock breeds adapted to organic production systems in all of the major U.S. agricultural regions will further enhance adoption, productivity, resilience, and ecosystem services of organic systems.

Research gaps for organic producers include the need for improved field monitoring and sensing technologies to assess soil heath, including efficacy of nutrient cycling and delivery to organic crops, as well as other management parameters such as moisture availability and onset of pest and disease problems. More information is also needed to help organic producers fine tune crop rotations, cover crop mixes, microbial inoculants or other soil microbiome management strategies, and pest management practices for their location and in real time (in response to weather and other changes).

Augmenting USDA funding for organic research to be commensurate with the market share of organic food will go far toward addressing specific research gaps for organic producers in a timelier manner.

H. Expand the Context and Substance of the Genome Design Cluster

We recommend conducting plant breeding, selection, and cultivar evaluation within the context of advanced soil health management such as organic, regenerative, conservation agriculture, and other agroecological cropping systems. Using existing biological and genetic resources, research should evaluate, develop, and optimize soil and plant microbiomes and crop genetics for crop vigor, resilience, and yield; nutrient and water use efficiency; and soil health and carbon sequestration. Research should also investigate the epigenetic effects of the management system, and genetic-environment interactions on crop-soil microbiome interactions, crop yield and quality, input efficiency, disease resistance, and resilience to drought and other stresses.

This research opportunity applies to all food, feed, fuel, and fiber crops, and to all systems and scales of production, but especially to systems that build resilience and help mitigate climate change through soil health management strategies, such as organic, regenerative, agroecological, agroforestry, and conservation agriculture.

Multiple lines of research in recent years indicate that interactions among crop genetics, management systems, and soil-plant microbiomes open opportunities to enhance cropping system resilience and yield stability, using existing biological and genetic resources – crop varietal diversity and indigenous soil, rhizosphere, and endophytic microbial communities. Best soil health management in conjunction with crop breeding and selection in healthy, biologically active and biodiverse soils can optimize crop-soil-microbiome relationships, thereby improving nutrient and moisture uptake efficiency, nutrient cycling, crop vigor and resilience to climate disruption, diseases and other stresses, soil carbon sequestration, and soil health. A few examples include:

1. Evidence that decades of breeding corn in the context of high nutrient-input conventional systems has diminished this crop's capacity to host nitrogen (N) fixing and other beneficial

microbes, but that a few generations of selection under organic or low external input management can reverse this trend and restore effective association with N fixing and N cycling microbes. *(Goldstein, W. 2015. Breeding corn for organic farmers with improved N efficiency/N fixation, and protein quality. https://eorganic.info/node/12972).*

2. Land races of sorghum partner effectively with mycorrhizal fungi to thrive and yield in low-fertility soils, while modern hybrids cannot, and thus fail without substantial fertilizer inputs. *(Cobb, A. B., G. W. T. Wilson, C. L. Goad, S. R. Bean, R. C.Kaufman, T. J.Herald, and J. D. Wilson. 2016. The role of arbuscular mycorrhizal fungi in grain production and nutrition of sorghum genotypes: Enhancing sustainability through plant-microbial partnership. Agriculture, Ecosystems, and Environment. 233 (3): 432-440).*

3. Carrots grown in organic and other advanced soil health management systems host more endophytic microbes that render the crop resistant to *Alternaria dauci* leaf blight than the same carrot cultivars grown conventionally. *(Abdelrazek, Sahir. 2018. Carrot Endophytes: Diversity, Ecology and Function. PhD Thesis, Purdue University. https://docs.lib.purdue.edu/dissertations/; Abdelrazek, S., and L. A. Hoagland. 2017. Potential functional role of carrot endophyte communities. Tri- Societies Meetings, Tampa, FL, October 2017).*

4. In central California, organically grown lettuce had much less corky root disease than conventionally grown lettuce. The former benefited from greater microbial activity and biodiversity, including disease-suppressive microbes. *(Ariena H. C. van Bruggen, Isolde M. Francis, and Randy Krag. 2015. The vicious cycle of lettuce corky root disease: effects of farming system, nitrogen fertilizer and herbicide. Plant and Soil 388 (1-2): 119-132).*

5. Large crop varietal differences in efficacy of mycorrhizal association have been documented in many crops including carrot, pepper, corn, other grains, and various legumes. Tomato, wheat, and other crops have shown similar variation in capacity to host disease-suppressive and systemic resistance-inducing microbes. Soil health conditions and nutrient management have pronounced impacts on mycorrhizal fungi and other beneficial soil microbiota; thus a major opportunity exists to optimize genetic (crop cultivar) X management interactions for nutrient efficiency, and crop resilience to disease, drought and other stresses. *(Schonbeck,M., D. Jerkins, and V. Lowell. 2019. Soil Health and Organic Farming: Understanding and Optimizing the Community of Soil Life. Organic Farming Research Foundation, 96 pp. https://ofrf.org/research./reports).*

6. An integrated strategy of rootstock genetic resistance, nutrient management, and beneficial soil microbes shows promise for controlling huanglongbing (citrus greening) in organic citrus orchards. *(Skiligo, A., and J. Shade. 2020. Organic Solutions to Control Citrus Greening Disease and its Vector, the Asian Citrus psyllid. Pages 13-14 in Proceedings of the 2020 Organic*

Agriculture Research Forum, Little Rock, AR, January 23, 2020. https://ofrf.org/research/organic-ag-research-forum/).

7. "Tightly coupled nitrogen cycling" in tomato grown under best organic management practices, which optimize plant genetic expression and rhizosphere microbiome to allow high yields in the presence of low soluble soil N levels that protect water quality and prevent nitrous oxide emissions. *(Bowles, T. M., A. D. Hollander, K. Steenwerth, and L. E. Jackson. 2015. Tightly-Coupled Plant-Soil Nitrogen Cycling: Comparison of Organic Farms across an Agricultural Landscape. PLOS ONE peer-reviewed research article. http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0131888).*

Challenges in pursuing this line of research further include the sheer complexity of genetic X environment X management interactions, and the diversity of epigenetic mechanisms by which crops respond to the environment in which they are bred, selected, and grown. A great volume of data must be collected, analyzed, and interpreted in order to identify and develop practical methods to realize these potentials. Additional challenges with "engineering" approaches to optimizing crop-microbiome partnerships, such as gene-editing and synthetic biology, include the research and development costs, as well as the substantial potential for adverse, unintended (and currently unknowable) consequences of the technology. Furthermore, these approaches are generally not applicable to organic producers (for whom USDA organic standards exclude genetic engineering and synthetic inputs) and other producers whose buyers or customers choose not to take the unknown agroecological and human health risks of these technologies.

As the sciences of in-field sensing, genomic and other -omic analysis, and data management and analysis continue to advance, a large and growing opportunity exists to expand our understanding and utilization of existing plant genetic diversity and naturally occurring soil and plant microbiomes toward crop production, nutrient and water efficiency, and ecosystem service goals. Utilizing indigenous soil microbiomes in conjunction with responsive, regionally adapted crop cultivars may yield more consistent and lasting benefits than introduction of microbes collected from outside the region, which are often simply overwhelmed and rendered ineffective by the indigenous biota, and which can, on the other hand, pose risks of becoming an invasive exotic microbe that upsets the indigenous microbiome. New crop cultivars with enhanced capacity to partner with soil microbes and other desired traits can be developed through conventional plant breeding assisted by genomics data, marker-assisted selection, data science, and farmer-participatory breeding communities of practice.

Outcomes will include new regionally adapted cultivars of a range of crops that partner most effectively with indigenous soil-crop microbiomes in healthy soils; improved understanding and management of plant-microbe partnerships; development of locally or regionally-derived microbial-guild inoculants designed either for broad application or specific crops and soil conditions; and guidance on advanced agroecological and soil health management systems that fully realize the potential of these crop cultivars and their microbial associates to utilize nutrients and moisture efficiently, ward off diseases and pests, and sustain yield stability in the face of drought and other weather extremes. Technological advances in the fields of remote sensing and automated data collection, data analysis and management, and genomic, phenomic, and metabolomic analysis can support these outcomes.

Research gaps include the lack of information on genetic X environment X management interactions, for the majority of food crops, cultivars, and agro-ecoregions. An increased investment in soil health research coupled with in-field plant breeding and crop cultivar selection in the context of indigenous microbiomes has a great potential of yielding safe, effective solutions for optimum production and resilience in a wider range of food, feed, forage, and fiber crops. Another important question to address is the potentially disruptive impact of microbial inoculants derived from outside of a given bioregion (i.e., invasive exotic microbes).

I. Focus Digital/Automation and Prescriptive Intervention/Data Science Innovations on Farmers

Digital and automation technologies should be primarily thought of as tools to aid farmers and ranchers in doing their jobs. As USDA considers field sensor and monitoring innovations within the digital/automation cluster, attention and prioritization should be given to the development of publicly available scale-appropriate technology to ensure that farmers of all sizes and scales benefit from these innovations. Additionally, control over technologies and ownership of data collected from technological tools should be carefully examined to ensure that farmers are the primary beneficiaries. Data collected from farmers should remain in the public domain, and it should be utilized not just to inform productivity but also ways to optimize economic viability, particularly for small and mid-scale farms. In addition, these innovations must empower farmers to do a better job of farming, and not put farmers and farmworkers out of work by automating entire operations.

J. Include USDA Data Integration and Analysis in the Digital/Automation Cluster

We support the inclusion of USDA's own data within the list of critical digital and automation needs. We strongly endorse the AGree Economic + Environmental Risk Coalition statement in response to the invitation for public comment:

> "Improved agricultural data integration and analysis is essential to addressing the most pressing questions facing the U.S. agricultural sector and American society at large. Questions that could be addressed by increased USDA data integration and analysis include:
>
> - How can agricultural enterprises become more efficient, resilient, and sustainable?

- How are yield variability and risk affected by different soil types for major crops?
- How are yield variability and soil type affected by conservation practices?
- What conservation practices, alone or in combination, work best, where?
- What conservation practices are most effective in reducing farm risk due to extreme weather events and climate variability?
- How can the food and agriculture sector develop and implement solutions to climate change? In doing so, how can we measure and verify those important contributions?
- What legislative and administrative policy changes are needed in order to make conservation practices, federal farm programs, and improved food security more cost-effective, efficient, and economically viable?

> USDA data sets have the potential to answer these questions, but they must be integrated and securely shared to perform the needed analysis. By integrating relevant USDA data sets and creating a secure, multi-layer querying system, government and land grant university researchers will be able to simulate and evaluate real time crop growth, risk, financial market impact, water quality and quantity impacts, and climate change mitigation and adaptation options."

As it pursues the Agriculture Innovation Agenda, USDA should put its own data systems front and center as low hanging fruit in need of cultivation and harvesting.

K. Ensure that Publicly Funded Research Serves Public Goals

We are concerned that the statement in the Federal Register notice for the Agriculture Innovations Agenda states that one of the objectives of the agenda is to "inform private product development" could alter the USDA's mission. As a federal agency, the USDA is mandated to serve public goals such as farm and rural community economic viability and social wellbeing; resource conservation and climate stewardship; and food security for all in the U.S. Publicly funded research should serve these goals. In contrast, private business interests place company and shareholder profits at the top of their priority lists. It is important that USDA-funded research not blur the line between public and private interests. While USDA research outcomes could indeed inform private interests as to the actual and current needs of producers, it is critical that USDA research programming, from grant application review through dissemination of project outcomes, be held to the standard of serving the public good.