2020 Annual Report of Accomplishments and Results

Washington
Washington State University

I. Report Overview

The NIFA reviewer will refer to the executive summary submitted in your Plan of Work. Use this space to provide updates to your state or institutions as needed.

1. Executive Summary (Optional)

Washington State University (WSU) Agricultural Research Center (ARC - the Agricultural Experiment Station of the State of Washington) and of Washington State University Extension collaborate to set consistent goals to conduct research beneficial to the citizens of Washington State and to extend relevant research results generated here and elsewhere, as well as research-informed programmatic engagement, to stakeholders within the state and beyond. We strive to create outcomes that improve the economic viability, environmental sustainability, community resilience, and quality of life for our people. We recognize that we have unique land grant research and outreach missions to serve the people of Washington to enhance their quality of life and to evaluate both short and long-term consequences of potential policies, decisions and actions. The constraints of the COVID-19 pandemic have made clear the need for long-term attention to delivery of Extension and outreach in place for those who have limited ability to directly access WSU central locations. The ARC provides leadership in discovering and accessing knowledge by carrying out high quality research that contributes to a safe and abundant food supply; promotes the well-being of individuals, families, and communities; encourages sustainability of agricultural and economic systems; promotes energy innovation; and encourages careful stewardship of natural resources and ecological systems. WSU Extension creates programs with measurable deliverables and outcomes that leverage the research base of the University and academia to address primary and timely issues in ways that lead to economic development, improved policy and governance, sustainability and resilience as well as personal, family, and environmental wellbeing. The synergy provided by integrating research capacity, problem-solving skills and the statewide engagement of ARC and Extension enables unique capacity to address pressing issues and problems while recognizing different perspectives. This maximizes the delivery of valuable contributions to our residents and society.

The WSU ARC and WSU Extension have many natural and structural links. Washington State University faculty have responsibilities that include both research and outreach, with many having formal joint appointments. This is particularly true within the College of Agricultural, Human and Natural Resource Sciences (CAHNRS), which houses both ARC and Extension. More than 100 faculty with ARC or Academic positions hold partial Extension appointments. An additional approximately 100 faculty have full Extension appointments with a primary focus on off-campus program delivery, applied outreach and direct engagement. The focus of our joint efforts is to provide science-based knowledge and outreach programs to meet the primary needs of the people of Washington State. As part of this core mission, the ARC has made significant commitments to focus on fourteen high priority research areas that advance our land-grant mission in discovery and development research. These research areas are (1) precision and automated agricultural systems, (2) soil-plant interactions: chemical, physical, and biological processes, (3) sustainable food production from livestock, (4) developing food processing, safety, quality, and supply solutions for production of high quality and safe food, (5) promoting health and wellness of individuals, families, and communities, (6) reducing the impact of pests and diseases affecting Washington agriculture, (7) crop improvement and sustainable production systems, (8) enhancing sustainability across diverse agricultural systems, (9) natural resources, (10) integrated research and societal engagement to address global water challenges, (11) functional genomics in animal improvement, food safety, and human health, (12) integrated crop and weed management systems, (13) molecular plant sciences: plant productivity in a dynamic environment, and (14) bioenergy and biofuel.

WSU Extension delivers significant outreach related to (1) natural resource stewardship; (2) food safety; (3) health and wellness; (4) youth and family development; (5) governance, (6) sustainability, and (7) community economic development. The efforts of ARC and Extension are a committed element of a broader set of programs addressing issues in these areas that reside in the many WSU colleges and interdisciplinary centers, including CAHNRS; the Voiland College of Engineering and Architecture; the College of Arts and Sciences; the College of Pharmacy; the College of Veterinary Medicine; the new Elson Floyd College of Medicine, and the Center for Environmental Research, Education and Outreach. Within Extension, specific examples of subject matter centers which conduct focused outreach efforts include the Food Systems Program, the Child and Family Research Unit, the AgWeathernet program, the William D. Ruckelshaus Center (a joint program with the University of Washington), the Division of Governmental Studies and Services, and the Metropolitan Center for Applied Research and Extension. Additionally, through close partnerships and collaborative agreements, our Research and Extension faculty also extend the research conducted by faculty at other regional centers of expertise, including among others the University of Washington, Oregon State University, and the University of Idaho. In 2020 Extension continued its initiative for developing stronger programmatic and project-based collaborations with the E.F. School of Medicine. In addition to activities focused on efforts to improve a statewide culture of health, on a pilot project to address agricultural worker behavioral health and suicide prevention, on response to a growing opioid crisis in the state, and more generally in connection to that college's unique distributed model for rural delivery of medical services and education to address health inequities, addressing the health concerns caused and made more immediate by the COVID-19 pandemic took on significant importance.

WSU researchers have garnered millions of dollars in extramural support to leverage their capacity grant funds into discovery and development research important to the citizens of Washington State. Between 2016 and 2019, WSU was the top university in the nation for total dollars awarded from USDA for research and development and over 80% of that total was from ARC and Extension faculty. The Northwest Advanced Renewables Alliance supported transformational research to make a sustainable aviation biofuels industry a reality which remains a strong initiative following the successful completion of that grant. The largest gift to Washington State University overall is still from the Washington Tree Fruit Commission, which approved check-off increases worth over $32 million over the eight years of the increased assessment for support of apple, cherry and pear research and extension. Other support in endowed professorships and research funding has been made available from organizations like the Washington Grain Commission (which has endowed several professorships at WSU and notably also donated over $5 million dollars to build a grains greenhouse), the Washington Potato Commission, the Washington Hops Commission and the Washington Wine Commission (which donated funding for the Ste. Michelle Wine Estates WSU Wine Science Center). There is a very vibrant relationship between WSU Research and Extension and numerous commodity- based entities in the state and region and we view this as a validation of the value placed on our efforts by our constituents and stakeholders. Our county partners contribute more than $10 million annually - in cash and kind - to support county Extension operations.

There are numerous societal, environmental and scientific challenges that can be addressed by cutting-edge research and through the application of that research to the practical issues that face the residents of Washington. Every year we assess and evaluate our research portfolio to strategically prioritize our efforts to ensure the greatest impact is derived from both our research and extension programs. As a result, we can continue to deliver important outcomes including economic benefits to agricultural and natural resource-based industries, government entities, communities, and individuals. Additionally, our research and outreach help ensure that the people of Washington State maintain a high quality of life by limiting the negative impacts of chronic disease, addiction, food insecurity, and obesity, and with the goal of eliminating health inequities. Finally, our programs help ensure that the beauty of the state and its natural resources are sustained for future generations. Our annual Report of Accomplishments endeavors to summarize the inputs, outputs, and impacts of our work conducted during the year.

II. Merit and Scientific Peer Review Processes

The NIFA reviewer will refer to your Plan of Work. Use this space to provide updates as needed or activities that you would like to bring to NIFA's attention.

Process	Updates
1. The Merit Review Process	Merit evaluation takes place at several levels. Prioritization for specific programs is manifested by allocations of effort and limited funds. In 2017 we implemented a new strategic prioritization of our Hatch capacity funds in order to better align with stakeholder needs and researcher capacity. We organized our research projects into fourteen main collaborative topic areas that were based on organic associations and are reflective of college strengths. Review and evaluation of research projects occurs prior to project submission and on an annual basis through REEport.
2. The Scientific Peer Review Process	Individual WSU faculty program plans are developed through statewide planning processes informed by the NIFA Plan of Work, the College of Agricultural, Human and Natural Resource Sciences Strategic Plan, and the WSU Strategic Plan (renewed in 2020). Faculty members are reviewed annually on a set of performance expectations that include: Effective program planning, implementation, and evaluation of impact; scholarly work and creative outreach materials; success with grants and extramural funding; leadership and teamwork; professional development; and service to the public and the institution. Annual merit ratings are assigned based on accomplishment within these categories, which are also the performance expectations considered for tenure and promotion of Extension Faculty. All faculty report at the end of the calendar year into our electronic Activity Insight database which can be accessed quickly at any time during the year that the information is needed. The progress of faculty work is reviewed by Program Directors, Department Chairs, Associate Deans and the Dean as an integral part of the annual performance review process. WSU faculty receive over 60% of their total funding from extramural sources, including USDA grants, grants from other agencies, foundation grants, and commodity commission grants. These funding agencies subject our proposals to expert peer review by scientific panels and by industry professionals and growers. All WSU Extension publications undergo a double-blind peer review. Reviewers include faculty at WSU or other Land Grant Universities, state and federal agencies, or research faculty at non-Land Grant universities.

III. Stakeholder Input

The NIFA reviewer will refer to your Plan of Work. Use this space to provide updates as needed or activities that you would like to bring to NIFA's attention.

Stakeholder Input Aspects	Updates
1. Actions taken to seek stakeholder input that encouraged their participation with a brief explanation	Stakeholder involvement is sought through a variety of means, including the following: • Relationship building through advisory councils, boards, regular meetings with key partners in local communities and state-wide • Workshops • Presentations at Commodity Commission Board and other state agency board meetings • Field Days hosted statewide • Engagement with Master Gardeners, Master Beekeepers, 4-H • Electronic media (email, listservs, websites, social media platforms, newsletters) • Radio • Direct mail • Telephone contacts • Social media at the College, Department, Program and individual faculty levels • Personal visits • Articles and stories in local, state, and regional periodicals, newspapers, magazines • Electronic surveys (using Qualtrics, Remark or Survey Monkey, and Turning Point software and clicker technology at workshops)
2. Methods to identify individuals and groups and brief explanation.	Annual assessments of general population characteristics, agricultural trends, natural resource- related issues, human health trends, and business dynamics are carried out as needed and are largely based on analysis of data collected by agencies external to the University, such as the US Census Bureau, National Agriculture Statistics Service, Washington Department of Natural Resources, Washington Department of Health, Washington Department of Agriculture, and the Washington Department of Commerce. To meet specific needs, these are supplemented in some cases by focused internal or stakeholder commissioned studies. These data help WSU faculty and staff and the commissioning stakeholders identify target audiences and define specific needs. We then develop appropriate research and outreach to address these needs.
3. Methods for collecting stakeholder input and brief explanation.	The ARC and WSU Extension use local and statewide advisory committees to provide input to the leadership, the faculty, and staff of Washington State University. These include the College of Agricultural, Human and Natural Resource Sciences (CAHNRS) Advisory Council, the Center for Sustaining Agriculture and Natural Resources Advisory Committee, advisory committees at each of the four Research and Extension Centers, and county, departmental, and program- specific advisory committees.

4. A Statement of how the input will be considered and brief explanation of what you learned from your stakeholders.	Input from stakeholders strengthens our ability to assess need and demand, and to identify potential partners, identify emerging issues, and to evaluate the effectiveness of our research and extension programs in addressing these issues and needs as we move forward with Research and Extension activities, initiatives and programs. Our programs are directly influenced by stakeholder feedback and input. The highest priority for our stakeholders is to support innovative research and extension outreach that addresses important issues that are critical to profitability, sustainability, and their health and well-being. Many stakeholders prioritize natural resources concerns related to water quality, water quantity, forest health, rangeland health, and stewardship. Local food systems and the desire for community connections with our food supply was another recurring theme, as was the desire to have us investigate new methods and practices for organic food production. Concerns over human health and diet, along with the growing incidence of obesity in our population were clearly stated as priorities and there was a desire to implement educational outreach to change behaviors. Consumer food safety education, positive youth development, and outreach to sustain rural communities were among several other stakeholder-defined issues that are being addressed by our current work. In 2020, other emerging issues such as the opioid crisis, access to affordable healthcare, and trust in government were made more immediate and exacerbated by the impacts of COVID-19.

IV. Planned Program Table of Contents

V. Planned Program Activities and Accomplishments

Please provide information for activities that represent the best work of your institution(s). See Section V of the Guidance for information on what to include in the qualitative outcomes or impact statements. Add additional rows to convey additional accomplishments. You may expand each row as needed.

No.	Title or Activity Description	Outcome/Impact Statement	Planned Program Name/No.
1.	**Advancing Soil Health in Washington State**	The State of Washington has a storied history of public-private collaborative leadership in soil health, including early research defining soil health and substantial early investment in soil conservation. In recent years there has been a growing focus on the need and opportunity to advance the next generation of soil health understanding and implementation in the state. This includes published research focused on assessing the potential environmental benefits of soil management (e.g. carbon sequestration), experimentation on new soil management practices, research on the impact of soil management practices on crop performance and nutrition and potential benefits on animal and human health, development and testing of various soil health diagnostic tools, and significant implementation of new soil conservation and soil building practices throughout the state. Overall Goal: To advance the understanding of soil health in Washington, establish a baseline of current soil health conditions, develop improved management options for improving soil health for a wide range of agro-ecosystems, and support on-farm implementation of soil health practices. Major Activities: • Major statewide road-mapping process underway. • A region-wide Soil Health Conference was held in Pendleton in March of 2019, with 151 attendees. • Submitted the Washington Soil Health Initiative as part of the WSU / WSDA / WSCC budget decision packages. Multiple presentations to various agricultural and industry groups.	Sustainability, Security and Resilience. Planned Program # 1.

		• WSU Soil Health Website developed and available at soilhealth.wsu.edu. Results/What Was Accomplished: -The Washington Soil Health Initiative was initiated with $250,000 from the Washington State Legislature. This initiative is an ambitious plan that funds research, extension, and demonstration of soil health best management practices through a network of long-term agroecological research and extension (LTARE) sites across Washington state's diverse agricultural systems. In 2021 the Washington Legislature reestablished this funding with significant investment. -The Pendleton "Healthy Soils, Healthy Region" conference extended soil health training to 151 agricultural professionals in the region, with 64% of participants indicating that the conference fully provided the information they hoped to learn regarding soil health, and 39% of participants indicating they had learned some of the information they had hoped to learn. Participants indicated that the most valuable new information learned during the event included the updates in soil health testing, making regional connections, information on soil and root development, and information on dryland cover crops. Participants were inspired to make several changes as a result of this event, including: learn more about soil health, talk with producers about soil health, utilize cover crops, hold field days and step up their collaborations. - Numerous stakeholders in the region requested information summarizing the potential for cropland agriculture to sequester carbon. A white paper summarizing regionally specific data was produced, was made available to these stakeholders. It has also been submitted to the WSU Extension publications system, has undergone peer review, and was revised and resubmitted in 2020.	
2.	**Extension Forestry Program**	Washington State has 225,000 families and individuals that control 5.9 million acres of privately-held forestland, making this the largest rural land use group in the state. Another 3.5 million acres of private land is grazed	Natural Resources. Planned Program # 3.

		as open and transitory rangeland. Most landowners manage for multiple objectives, such as timber and livestock production, along with wildlife habitat improvement and a variety of recreation opportunities. RREA funds (7:1, worth $500,000) were leveraged to support seven forestry and rangeland specialists, who this year adapted their normal programming to digital delivery (synchronous and asynchronous) to serve a larger and more diverse audience than in previous years. WSU Extension and the RREA program have improved the ecological condition and economic well-being of communities in every county in Washington State. In 2020, Extension Forestry continued to build on the outcomes of a 10-year outreach and education campaign to improve forest health and wildfire risk mitigation in eastern Washington. The longitudinal evaluation results reveal that Extension Forestry influenced best management practice treatments on at least 247,500 acres. Over 22,000 families accomplished management objectives, reduced risk, and protected their financial investments after participating in one or more of 350 hands-on demonstrations, workshops, field days, and short courses. Goals achieved: improved forest health, improved productivity for growing trees, increased tree cover, improved income prospects, decreased noxious/ invasive weeds, improved habitat, decreased risk of erosion, decreased risks from insects or disease, protected cultural resources and improved recreational opportunities.	
3.	**Master Gardener Program**	Food security was made a more pressing issue in American's lives by the impacts of COVID-19. Food security means access by all people at all times to enough food for an active, healthy life. According to the USDA, an estimated 11.1% of U.S. households were food insecure in 2018, which is an improvement from 11.8% in 2017 and from a peak of 14.9% in 2011. About 56% of food insecure households participated in one or more of the three largest Federal food and nutrition assistance programs, SNAP, WIC and the National School Lunch Program.	Sustainability, Security and Resilience. Planned Program # 1.

		Research indicates food banks play a major role in reducing food insecurity, particularly when nutrient rich foods such as fresh fruits and vegetables are available to hungry families. Additionally, families who grow their own food are more likely to eat fresh produce than families who do not. The WSU Master Gardener volunteers taught food gardening to communities across the state, with participation at the national and international level made possible by the newly-adopted distance delivery mechanisms in an effort to close the food security gap and to support the consumption of healthy food.	
4.	**Food Safety and Preservation**	According to the USDA, the Colville Reservation and some parts of Okanogan County are a Food Desert, which means residents in the rural communities have to travel more than 10 miles to get safe, affordable, healthy fresh foods (https://www.ers.usda.gov/data-products/food-access-research-atlas/go-to-the-atlas.aspx). When Reservation and County residents do get fresh fruits and vegetables, safely preserving them allows those nutritious foods to be eaten year-round. Another need that is unique to the Colville Reservation and further justifies the need for food safety and food education is the sheer number of traditional, large gatherings that involve food handling, food preparation, serving food and subsequent food storage. On the Colville Reservation, it is a challenge to educate people that the way grandma and great- grandma traditionally handled and preserved food was more out of necessity, rather than safety. In partnership with the Colville Confederated Tribes (CCT) Food Distribution Program and the CCT Area Agency on Aging Program, produced and distributed copies of the 2020 Nutrition and Food Sovereignty Calendar. Given the renewed interest in home cooking and preservation, the Electric Pressure Cooker Workshops had high attendance numbers. These	Fostering a Culture of Health. Planned Program # 5.

		presentations increased participants' desire to purchase and own an electric pressure cooker, as shown by this participant's evaluation: "I do not yet own an electric pressure cooker but was excited to hear about this class to help me decide if I want one."	
5.	**Forestry Youth Success Program**	As a county with 90% forested lands, Skamania County Washington provides a unique opportunity for its residents to connect with the beauty and the function of the forest that surrounds them. Many teens in Skamania County are unaware of the role forests play in their region. Additionally, the lack of opportunities that have resulted from economic changes due to a downturn in the local timber industry create a barrier to obtaining the job experience and real world skills these teens need to be successful. At the same time, a multitude of local agencies lack the manpower to complete projects benefiting the health of the Gifford Pinchot National Forest (GPNF) and other county natural assets. Washington State University Extension, Stevenson-Carson Public Schools, and Mt. Adams Institute partner to provide Forest Youth Success. The primary goals of the program are to provide opportunities for youth development and employment as well as maintain the health of the local forest. The program provides basic job skills in a paid-work setting focused on environmental stewardship. This program shifted to remote delivery and was restructured in anticipation of full resumption in 2021, post-COVID.	Natural Resources. Planned Program # 3, AND 4-H Youth Development. Planned Program # 4.
6.	**Age Friendly Housing Research**	A multi-agency project led by CED's Metropolitan Center and Division of Governmental Studies and Services assessed the Puget Sound area's projected needs for senior housing. The "Moving Toward Age-Friendly Housing in King County" report found that the number of older adult-led households is on track to outpace the supply	Community and Economic Development. Planned Program # 2

		of accessible and affordable housing in King County. Half of senior households who rent are already cost-burdened, as are 40% of those with a mortgage. Recommended strategies ranged from updating land use policies to allow cottage clusters and accessory dwelling units to increasing funding for home delivery services. They also recommended building senior housing units near established services to provide for daily needs, socialization, and transportation.	
7.	**University Emergency Management**	For nine years WSU Extension (through the CED unit Division of Governmental Studies and Services) has provided Emergency Management services for the University, with an emphasis on the Pullman campus. This unit provides all phases of emergency management: Planning/Training/Exercises, Mitigation & Preparation, Response, and Recovery support for the greater university community and partners. Notable accomplishments have been the finalization of a joint Comprehensive Emergency Management Plan in partnership with the City and County in which the Pullman campus is located. This role took on critical importance in providing staff, expertise and critical networking to support the University response to COVID-19.	Sustainability, Security and Resilience. Planned Program # 1, AND Community and Economic Development. Planned Program # 2.
8.	**Community and Economic Development Centers**	*The WSU Extension Community and Economic Development Program Unit faculty and staff partner with local leaders to improve their communities and grow their economies.* • ***The Division of Governmental Studies and Services (DGSS)*** *engages faculty and students across the university in applied research, technical assistance and training related to public safety, governance and sustainability and digital initiatives, using that unique project experience to address issues throughout the region.* • ***The Metropolitan Center for Applied Research and Extension*** *puts the people's university to work for Washington's cities, bringing WSU's world-class expertise to help inform data-driven decisions and implement change that works.*	Community and Economic Development. Planned Program # 2.

		• ***The William D. Ruckelshaus Center*** *is a unique joint venture of WSU and the University of Washington with a mission to help parties involved in complex public policy challenges in Washington state and the Pacific Northwest tap university expertise to develop collaborative, durable, and effective solutions.*	
9.	**4-H Tech Changemakers**	More than 24 million people living in the U.S., including 19 million living in rural communities, do not have access to broadband internet—an essential service in today's economy. Washington is no exception. Limited access to broadband internet, combined with the growing need for digital skills, is impacting access to economic opportunities for youth across the nation. That is why WSU Extension is advancing and promoting the 4-H Tech Changemakers program which empowers 4-H members to lead digital skills trainings, teach the value of digital tools, and find technological solutions to real world problems. With funding from Microsoft through the National 4-H Council and expert leadership, 4-H Tech Changemakers are making a lasting impact on the communities that need it most.	4-H Youth Development. Planned Program # 4, AND Sustainability, Security and Resilience. Planned Program # 1.
10.	**Broadband Action Teams**	Broadband Action Teams (BATs) are critical networks that increase local engagement by helping to provide broadband access to underserved rural communities. Between 2012 and 2014, the Washington State Broadband Office, with funding from NTIA's State Broadband Initiative, offered more than a dozen grants to form Local Technology Planning Teams (LTPTs). WSU Extension led or played a key role in over half of the LTPTs. Coupling WSU Extension community engagement expertise and lessons learned from the LTPT efforts, the BAT model was developed and is being facilitated in communities across the state.	Sustainability, Security and Resilience. Planned Program # 1, AND Community and Economic Development. Planned Program # 2.
11.	**Agricultural Worker Behavioral Health and Suicide Prevention**	In 2018, the Washington State legislature passed legislation to address suicide in the agriculture industry, and WSU Skagit County Extension was selected by the Washington State Department of Health to develop a suicide prevention pilot program for farmers and farmworkers. During	Fostering a Culture of Health. Planned Program # 5, AND Sustainability,

		the initial stage in 2019 and after full implementation in 2020, program efforts included collaborating with suicide prevention and behavioral health experts, building institutional capacity, such as bilingual English–Spanish material and website creation, and leveraging the Extension platform. We provide a roadmap for other entities looking to create suicide prevention programs.	Security and Resilience. Planned Program # 1.
12.	**Women in Agriculture**	Women face unique challenges growing viable businesses in farming and ranching. They are often not taken as seriously as men when seeking loans and insurance, may feel unwelcome at farm meetings predominantly attended by men, and often need off-farm income which requires working during the day and farming on evenings and weekends. This statewide program for women involved in agriculture provides risk-management and financial management education, as well as guidance in mitigating problems in running their businesses. Truly a multi-disciplinary program with participating faculty from all three WSU Extension units, the 2020 program reached more than 700 women from six states.	Sustainability, Security and Resilience. Planned Program # 1, AND Community and Economic Development. Planned Program # 2.
13.	**Molecular Plant Science: Plant Productivity in a Dynamic Environment**	The productivity and fitness of crop plants are determined by a multitude of factors, which form a network of highly integrated metabolic pathways that enable plants to dynamically respond to challenging environmental conditions. Understanding these factors becomes highly relevant for society in general and for U.S. agriculture in particular due to global climate change and the need for sustaining food production. An indispensable foundation for improving crops is better knowledge of plants' fundamental mode of action ranging from nutrient/water usage efficiency, resilience against biotic and abiotic stresses, perception and interpretation of signals from the environment and from inside the plants, conversion of sunlight to primary metabolites, and further to valuable secondary metabolites. The overall goal of the Molecular Plant Science (MPS) umbrella project is to advance our understanding of the molecular basis of plant and crop productivity and to describe the mechanisms of how plants survive and thrive in a challenging, changing, and often unpredictable environment. The project addresses five of the six USDA-NIFA challenge areas: Food Security, Climate Variability and Change,	Sustainability, Security and Resilience. Planned Program # 1

		Water, Bioenergy, and Food Safety. By focusing on basic aspects of plant biochemistry, physiology, and molecular biology, this project produces the scientific knowledge for laying the foundation for urgently needed advances in crop productivity, quality, and environmental robustness. The umbrella group focuses on five main areas to achieve a holistic understanding of how plants function in dynamic environments: primary metabolism, secondary metabolism, signals and hormones, stress response, and root functions. The MPS Hatch umbrella group made significant progress in the following areas. *Primary metabolism*: We uncovered a new role of lipids for photosynthetic energy conversion, and for the integral regulation of starch and photosynthesis. *Secondary metabolism*: We defined the production limits for healthy high-oleic oils for canola while eliminating non-healthy trans fats. Furthermore, we gained novel insights into the control of fatty acid fluxes that allowed the engineering of these fluxes to increase plant oil production. For the first time, the chemical composition of pantropical whisk fern was determined by MS and NMR spectroscopy. *Signals and hormones:* We discovered the unique roles for calcium/calmodulin-mediated signaling in launching and fine-tuning plant immune response and we further defined the dual role of ATP as energy equivalent and danger molecule. *Stress response*: We generated potato plants with enhanced resistance against soilborne pathogens (e.g., nematodes). We developed a novel method of transferring alien genes from wild relatives to crop plants in a targeted and precise manner that can be used to improve stress response in wheat plants. We advanced our research on the specificity of elicitors for activating antifungal responses in pea. Furthermore, we determined the genetic mechanism for the development of vascular pit membrane in grasses and showed that pit membrane thickness positively correlates with drought survival. *Root functions*: In collaboration with NASA, we investigated whether symbiotic nitrogen fixation can occur in space and whether these plants no longer need to make as much lignin in the absence of gravity. We engineered strains of soil microorganisms to excrete ammonia, and showed that the ammonia is taken up by crop plants. Finally, we uncovered the role of auxin fluxes in shifting root growth from anisotropic to isotropic.	

14.	**Effects of Biodegradable Plastic Mulch on Soil Health**	Plastic mulches are an important component of many agricultural production systems, ranging from annual horticultural crops to perennial tree fruits systems. While plastic mulches provide multiple benefits, such as weed suppression, increased soil temperatures, and water savings, the drawback is that these mulches have to be removed from the fields after the growing season or at the end of their use. Contamination with soil hinders recycling, so that the mulches must be disposed of in landfills or stockpiled on-farm. Biodegradable plastic mulches, which are designed to degrade to carbon dioxide and biomass in soil, are a promising alternative, alleviating the disposal issues common to conventional plastic mulches. However, it must be demonstrated that the use of biodegradable plastic mulches does not cause harm to the soil ecosystem. A multi-year collaboration between Washington State University and the University of Tennessee was established involving a transdisciplinary team of scientists, farmers, industry representatives, and non-profit organizations to address the issues of suitability and sustainability of biodegradable plastic mulches for agriculture, with a focus on annual horticultural vegetable production. Our team specifically focused on evaluating the impacts of biodegradable plastic mulches on soil health. Multi-year field trials were established to compare the performance of biodegradable plastic mulches against conventional plastic mulches in terms of impacts on various soil quality parameters. No differences between conventional and biodegradable plastic mulches were observed in terms of physical, chemical, and biological soil quality parameters. Compared to the no-mulch treatment, the soil-biodegradable plastic mulches and conventional polyethylene mulch increased the soil aggregate stability and water infiltration rate by protecting the soil surface from disturbance. Residual soil nutrients under the plastic mulch after harvest were lower than under no-mulch due to increased yield and associated enhanced nutrient uptake. Accordingly, less leaching of	Sustainability, Security and Resilience. Planned Program # 1

		nutrients, especially nitrate, was observed under the plastic mulches. Within the four-year period, the soil-biodegradable plastic mulches had overall positive effects on soil and groundwater quality. However, longer studies are needed to ensure long-term sustainability of biodegradable plastic mulches. Use of agricultural plastic films is expected to increase by 59% from 2018 to 2026. This increase will lead to increased waste and associated pollution of agro-ecosystems with conventional plastics. The results from this project demonstrate that biodegradable plastic mulch films can be a valuable alternative to conventional polyethylene mulch films. Although the cost of biodegradable plastic mulch films is about 3 times higher than that of polyethylene mulch films, the long-term environmental benefit of reducing plastic waste may outweigh the higher initial cost.	
15.	**WSU Health & Wellness Project**	While the United States spends more on healthcare than any other country in the world, Americans score lower than average on many health indicators when compared to other countries in the Organization for Economic Co-operation and Development. To improve the health and wellness of all Americans, evidence-based research and outreach is greatly needed. This collaborative research project, conducted by WSU faculty across disciplines, was formed to collectively advance health-related knowledge and scholarship and translate newly gained knowledge through educational and community-based activities. The overall goals to: (1) Advance and extend the empirical knowledge base of health and wellness through scholarly activities across a wide range of academic disciplines and, (2) Based on research findings, translate knowledge to outreach, educational, and community-based activities to improve the quality of life of individuals, families, and communities were made significantly more important and relevant by COVID-19.	Fostering a Culture of Health. Planned Program # 5

		Previous research into the impact of the Affordable Care Act (ACA) on impoverished families in rural areas found that many families generally appreciated the ACA, but the appreciation was not directly related to easier access to healthcare and quality care. Most of the families expressed strong distrust toward the healthcare system, healthcare providers, and policymakers. Specifically, the majority felt their insurance status is tenuous, policymakers do not understand the reality of their situation, and healthcare providers do not listen to their concerns. Accordingly, the families' first action when a family member becomes sick is to reach out to friends and family members for medical information instead of going to a healthcare provider. Research results were shared with a wider audience through peer-reviewed journal publications and conference presentations. This research supported enhanced outreach through a collaboration with the Elson S. Floyd College of Medicine.	
16.	**Crop Improvement and Sustainable Production Systems**	This project sought to enhance sustainability and profitability of production systems for important crops in Washington State, the region, and the nation. Participants pursued a collaborative, multidisciplinary strategy that brought together expertise in plant breeding, crop physiology, and the rapidly-advancing areas of genomics, phenomics, and bioinformatics. We applied our combined disciplinary strengths—including genotyping, quantitative and statistical genetics, bioinformatics, and physiology—toward plant breeding to support diverse crop improvement programs and maximize our impact on cropping systems, farm profitability, rural livelihoods, and food security. This research was complemented by extension activities in outreach and stakeholder engagement associated with apple, blueberry, grape (juice and wine), pear, potato, raspberry, strawberry, sweet cherry, and wheat.	Sustainability, Security and Resilience. Planned Program # 1, AND Community and Economic Development. Planned Program # 2.

		We developed data sets and tools to facilitate basic, translational, and applied research associated with cultivar development by using the selection criteria generated by the computing pipeline. The breeders used DNA-informed techniques to select new genetic material and to evaluate disease resistance (e.g., fire blight in apple). We identified new elite selections/cultivars and showed them to growers at field days and industry meetings. The project helped release for production two Soft White Winter Wheat cultivars ("Devote" and "Stingray CL+"); two Hard Red Winter Wheat cultivars ("Scorpio" and "WA8252"); and one Red Raspberry (WSU 2166'). We also developed specific management of selections/cultivars in the different species to optimize water use, pruning, yield, and product quality. Breeders (target audience) had access to a comprehensive breeding information management system that allowed them to fully manage and analyze data from their programs while also connecting to public data and tools for further analysis. Researchers of Rosaceae species (apple, pear, cherry), pea, lentil, chickpea, and fava bean also had access to curated and integrated data and tools to enable their research. In addition, growers (target audience) had tools and strategies to improve yield and fruit quality in different species. The final beneficiary of all these innovations was the consumer (target audience), who had new genetic resources characterized by higher eating quality. Our studies produced new genetic material (selections/cultivars) and technical information about the agronomical management of the different species for the growers. The combination of these factors resulted in high quality food production for the consumers.	
17.	**Reducing the Impact of Pests and Diseases Affecting Washington Agriculture**	According to the Northwest Horticultural Council (www.nwhort.org), sweet cherries are produced on 53,000 acres in the Pacific Northwest (PNW). Washington State leads with 40,000 bearing acres, followed by California and Oregon (USDA-NASS). Approximately 50% of planting stock	Sustainability, Security and Resilience. Planned Program # 1, AND

		for new orchard establishments comes from Washington nurseries. One of the primary diseases of sweet cherry in Washington is powdery mildew, caused by Podosphaera cerasi. The disease is managed using intensive fungicide programs. Despite these intensive programs, we have noticed an increase in the amount of control failures. This led to our ongoing research on fungicide resistance in cherry powdery mildew. The PNW cherry industry has long depended on various synthetic fungicide classes: FRAC Group 11 (QoI or strobilurin), FRAC Group 3 (DMI or SBI Class-I), FRAC Group 7 (SDHI), and FRAC Group 13 (quinoline, quinoxyfen, Quintec). Many of the observed control failures occurred in programs that significantly relied on Group 11 fungicides. Given the documentation of widespread resistance of the grapevine powdery mildew pathogen (Erysiphe necator) in Eastern Washington, and the epidemiological similarities between the powdery mildews of grapes and cherries, we suspected a similar scenario in PNW cherries. Cherry production in Washington state and the greater PNW is a major economic driver, and the impacts of fungicide resistance in this industry will be profound. It is the mission of our research program to identify fungicide resistance across sites-of-action and to develop new management programs for areas where resistance is a problem.	Community and Economic Development. Planned Program # 2.
18.	**Drive-up WiFi Access Project**	As WSU adapted to the operational constraints imposed by the response to the COVID-19 pandemic, it became increasingly clear that access to reliable broadband was a necessity for continued economic, academic and health success that was not readily available to all, especially among rural and under-represented populations. WSU Extension proposed activating parking lot access points for broadband WiFi by installing exterior routers at Extension and partner locations. With funding from Microsoft and the state, Extension began installing “Drive-up WiFi” sites across our statewide network to provide access. Our partnership with the Washington State Broadband Office allowed that early effort to be multiplied by the addition of other partners and application of significant support to generate what	Community and Economic Development. Planned Program # 2.

		now is a network of over 600 locations available for public access across the state. The network can be explored at: https://www.commerce.wa.gov/building-infrastructure/washington-state-drive-in-wifi-hotspots-location-finder/	