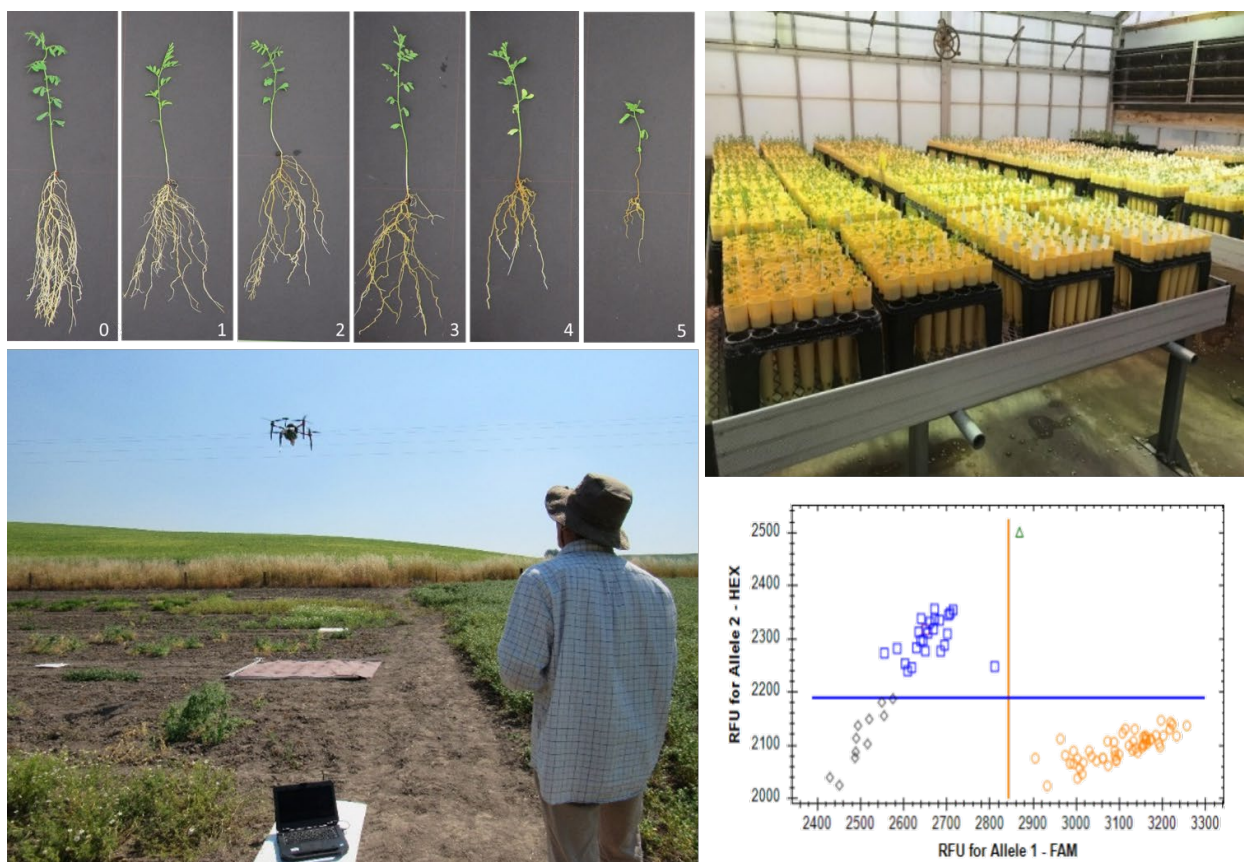


Calendar Year 2020 - Activity Report

USDA-Agricultural Research Service
Western Regional Plant Introduction Station (WRPIS)
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Table of Contents

EXECUTIVE SUMMARY	3
2020 Highlights	3
Cover Story	4
ADMINISTRATION	5
PERSONNEL	5
PROJECTS	6
FUNDING	6
FACILITIES	7
GERMPLASM MANAGEMENT	9
Acquisition	11
Conservation	12
Characterization/evaluation	12
Distribution	13
Utilization - Western States	14
1. Agronomy (Cool season grasses and Safflower) Program	16
2. Cool Season Food Legumes Program	16
3. Temperate-adapted Forage Legume & Native Plants Programs.....	18
4. Horticultural Crops Program.....	20
5. <i>Phaseolus</i> /Bean Program	21
MISSION-RELATED RESEARCH PROGRAMS.....	22
1. Alfalfa Genetics Program	22
2. Plant Pathology Program	23
3. Pulse Genetics Program	25
COMMITTEES, PRESENTATION AND SERVICE.....	25
Peer reviewed.....	26
Abstracts/Conference Presentations.....	27
APPENDIX I – Multistate Review Committee (MRC) Recommendation.....	29
APPENDIX II – WRPIS Staffing	30
APPENDIX II – Research, Service and Outreach Activities	32

EXECUTIVE SUMMARY

The Western Regional Plant Introduction Station (WRPIS) is one of four regional plant introduction stations in the United States. Activities at WRPIS focus on acquisition, preservation, characterization, evaluation, documentation and distribution of assigned plant genetic resources and their associated information along with conducting mission-related research. This Station includes five curatorial programs and two research programs (alfalfa genetics and a vacant Research Leader-led program). The operation is primarily funded by three CRIS projects [two belong to National Program (NP) 301 and one to NP 215] managed through the USDA ARS Plant Germplasm Introduction and Testing Research Unit (PGITRU), on the Washington State University (WSU) campus in Pullman, WA. The Temperate-adapted Forage Legume (TFL) Germplasm and the Alfalfa Genetics Research projects are on an ARS worksite in Prosser, WA co-located with the WSU Irrigated Agriculture Research and Extension Center (IAREC). The W6 Regional Multistate Research Project associated with the Station also contributes considerable funding (~12% of the total operating budget) to support its mission. Funds are managed through the State Agricultural Experiment Station (SAES) and originate from the Hatch Multistate Research Fund (MRF) managed by the National Institute for Food and Agriculture and originating from the USDA. The W6 funds cover the salary and fringe benefits for six full-time state employees working for the WRPIS as well as partial land costs, supplies/equipment and farm operations for regenerations, characterization, evaluation, and enhancement research. Goals are achieved through close collaboration among scientists with diverse expertise in fields like agronomy, horticulture, plant pathology, genetics, plant physiology and botany. The W6 project is implemented in close association and collaboration with scientists of SAES, other state and federal agencies as well as the private sector. The station's scientists also actively collaborate with colleagues at international centers, universities, and non-governmental organizations. Guidance for project implementation comes from USDA National Programs and the Pacific West Area Office as well as from the W6 Regional Technical Advisory Committee (RTAC). The global crop plant research community continued to utilize extensively WRPIS germplasm collections. In 2020, 36,790 germplasm samples (e.g., seed packets) were distributed in 746 orders to each of 47 U.S. states and to 28 countries. WRPIS scientists also made 16 poster or oral presentations at various regional, national, and international conferences, and participated in 11 peer-reviewed research publications.

2020 Highlights

- A new 5-year W6 Regional Multistate Research Project proposal was drafted, submitted, and approved with minor revisions by the Multistate Review Committee (**Appendix I. MRC Recommendation**).
- At the beginning of 2021, there were 99,877 accessions belonging to 955 genera, 4,360 species (4,988 taxa) in the WRPIS collections with the site accounting for ~17% of the active NPGS accessions.
- In 2020, 883 accessions were acquired including 766 native plant accessions collected by the Seeds of Success (SOS) program.
- A total of 36,790 seed samples packets were distributed in 975 orders to 577 unique requestors with addresses in 47 domestic states and the District of Columbia, and 28 foreign countries. 76% percent (28,092 packets) were distributed to the U.S. and 24% (8,878 packets) were distributed internationally. A total of 5,508 packets from WRPIS went to all 13

Western states in 196 orders. Requesters in all domestic states received germplasm samples from WRPIS during the reporting period with a total of 5,508 packets (i.e., order items) from WRPIS went to the 13 Western states.

- A total of 456 observation data points on 456 accessions were uploaded into the Germplasm Resources Information Network (GRIN)-Global database. These data points were for 8 established descriptors of 3 different crops. Collaborators contributed 3% and WRPIS staff provided 97% of the evaluation data. In addition, 2,651 voucher images were uploaded to GRIN-Global with most of them being seed, flower, and leaf images.
- Seed viability records uploaded to GRIN-Global totaled 813 during the reporting period. The National Laboratory for Genetic Resource Preservation (NLGRP) in Fort Collins, CO tested 755 accessions, and 58 were tested by the Horticultural Crops curatorial program.
- A total of 1,270 seed inventories were shipped to the NPGS National Laboratory for Genetic Resource Preservation (NLGRP), Fort Collins, CO for secured backup.
- Large sets of alfalfa and wild relative germplasm accessions were screened for disease reaction to spring black stem. The research produced improved inoculation and scoring procedures, more clearly defined host range within *Medicago* and allowed for resistant selections to be made for improved pre-bred populations.
- In 2020, the Native Plant Program and the Horticultural Crops Program, investigated effects of different stratification regimes and seed temperatures on optimized seed germinations in five native *Astragalus* (milkvetch) species. Generally, results indicate a 2-week stratification and cooler temperatures produced optimal germinations for these species.
- The WRPIS Lentil Core Collection was screened for disease reaction to *Aphanomyces* root rot, with resistant germplasm identified. Significant marker trait associations identified in genome-wide association studies allowed for breeder-friendly kompetitive allele specific PCR (KASP) markers to be developed for use in markers assisted breeding efforts.
- A collaborative team led by Long-Xi Yu, mapped genetic loci associated with alfalfa verticillium wilt resistance in a biparental population and identified two candidate genes. Candidate gene sequence variants were used to develop several breeder-friendly markers.

Cover Story

Aphanomyces root rot (ARR) is one of most devastating diseases in lentil production in the U.S. The USDA National Plant Germplasm System, WRPIS Lentil Core Collection was screened for disease reaction under both controlled greenhouse conditions as well as in a dedicated field root rot nursery. Resistant germplasm was identified, and significant marker trait associations were identified in genome-wide association studies. From these marker associations, breeder-friendly kompetitive allele specific PCR (KASP) markers were developed for use in markers assisted breeding efforts. This was a collaborative project between USDA WRPIS (Clarice Coyne), USDA Grain Legume Genetics (Rebecca McGee) and WSU Departments of Horticulture (Yu Ma, Dorrie Main) and Biological Systems Engineering (Sindhuja Sankaran).

Figure Legend. From top leaf and clockwise. Rating scale used for scoring lentils showing varying degrees of disease resistance/susceptibility to *Aphanomyces* root rot; Lentil plants in replicated greenhouse screening assays; Breeder-friendly kompetitive allele specific PCR (KASP) markers were developed for marker-assisted selection for root rot resistance; and Root rot field nursery for assessing germplasm using an aerial drone flown by Chongyuan Zhang.

ADMINISTRATION

Scot Hulbert (Administrative Advisor)
Ed Kaleikau and Ann Stapleton – (NIFA Representatives)
Peter Bretting (ARS National Program Staff)
Robert Matteri (ARS PWA Area Director)
George Vandemark (ARS Acting Research Leader and Station Coordinator)
Carla Olson (ARS Program Support Assistant)

Calendar year 2020 was difficult for everyone as our work and lives changed as the COVID 19 Pandemic unfolded. It was a challenging time for WRPIS as social distancing, mandatory telework, and closure to USDA and WSU facilities impacted mission activities. In addition, several key vacancies reduced capacities and outputs. Despite obstacles, the WRPIS was able to continue operations and deliver on its critical mission of acquiring, conserving, characterizing, and distributing valuable plant genetic resources and their associated information.¹

PERSONNEL

Several key personnel changes occurred in both the federal and state-funded projects in CY 2020. Recruitment for three of the Unit's permanent scientific staff is currently underway. The **PGITRU Research Leader/Supervisory Research Geneticist/Plant Pathologist** was advertised and interviews were being conducted in May and June 2021. A Unit Research Leader and WRPIS Station Coordinator should be onboard by early Fall 2021. Interviews for the **Agronomy** (cool season grasses and safflower) **Curator** vacant since 2018 were conducted in March 2021, a tentative offer has been made and accepted, and the position should also be filled by early Fall 2021. Announcements and application deadline for the **Curator for Phaseolus/Bean** program also occurred in March 2021. Hiring manager (Acting RL) and search panel will be working to identify candidates for interviews. A USDA federal **Postdoctoral Research Associate**, Lyle Wallace, was recruited for two years to conduct *Phaseolus* germplasm research, with salary offsets from vacant **Phaseolus/Bean Curator** position. Due to budgetary constraints, decisions were made to abolish the Unit's **Research Plant Pathologist** position (vacant since 2018) and a Prosser-based vacant **Biological Science Technician** position created by a retirement in 2017. Melissa Scholten was recently hired into a **Biological Science Technician** position to take over seed germination duties, a position that had been vacant since 2019. A vacancy was created in the Unit's **IT Specialist** position, after Bo Gao resigned in 2020. This position, will no longer be filled at the Unit level and most likely will be integrated into the USDA's Client Experience Center (CEC) which is a federal government information-technology service provider that uses a business model to support the comprehensive IT requirements of federal business. In addition, William Luna also resigned from a **Biological Science Technician** position responsible for greenhouse maintenance and efforts are underway to recruit a replacement for this critical position.

For the first time in many years, the W6-supported WRPIS project team is fully staffed. Jaqueline Cruver retired after a long career with the Unit in 2020. The position she occupied as a

¹ WRPIS 2020 Activity Report was prepared by Brian Irish, with collective efforts from WRPIS staff

Plant Technician was quickly recruited and filled by David Van Klaveren, who is mostly dedicated to aiding in seed distributions/requests.

PROJECTS

For plant genetic resources management, there are two base funded projects entitled “Management of Priority Legume, Oilseeds, Vegetable, Forage Grass, Sugar, Ornamental, and Medicinal Plant Genetic Resources and Associated Information”, based in Pullman and “Management of Temperate-adapted Forage Legume Genetic Resources and Associated Information”, based in Prosser. Both projects are relevant to USDA Agricultural Research Service, National Program 301- Plant Genetic Resources, Genomics, and Genetic Improvement and are due to begin a new 5-year cycle in 2023. Discussions are in progress to combine these two projects due to underfunding for the Prosser-based project.

The alfalfa genetics research project conducted at the Prosser worksite is entitled “Enhancing Resistance to Biotic and Abiotic Stresses in Alfalfa”. This project is relevant to USDA Agricultural Research Service National Program 215 - Pasture, Forage, and Rangeland Systems. Its previous five-year cycle ended in 2019 and is due to be renewed in 2024.

The current USDA-NIFA W6 Regional Multistate Research Project entitled “Management and Utilization of Plant Genetic Resources and Associated Information” is in its fifth and final year of the 5-year cycle. A renewal proposal for the next 5-year program cycle was submitted late in the 2020 CY for review. A new 5-year project cycle would begin October 2021.

FUNDING

The total federal ARS budget for the PGITRU was \$3,257,476 and includes the budgets for the Pullman-based germplasm (\$2,539,778), the Prosser-based temperate-adapted forage legume germplasm (\$275,939) and alfalfa genetics research (\$441,759) projects. After indirect costs are assessed, net balance was \$2,894,672 with \$2,664,577 dedicated to salaries and remainder for supplies, equipment, and extramural agreements. The discretionary dollar amount per SY (8 in the Unit in 2020), an indicator of the financial health of the Unit, was \$22,900. The ‘in kind’ support from the W6 Western Regional Multistate Research Project, through Washington State University, was \$456,000.

In 2020, TFL Curator Brian Irish led a NIFA-ASAFS research project entitled “Developing Regionally-adapted, Resilient Alfalfa Germplasm Pools” with \$60,000 to ARS-Prosser (2019-2021). This project is a collaboration with the University of California and cover salaries for temporary technical staff. In addition, the TFL Curator has been leading an inter-agency project between ARS and Bureau of Land Management (BLM) focusing on native plants. The project is entitled “Management, Evaluation, Acquisition, and Distribution of Native Plant Germplasm for Research and Restoration” with 2020 funding of \$156,084.14 that covers a full-time Support Scientist (Mike Cashman), a part-time collaborator and three temporary employees. The BLM collaboration funding also covers some travel and needed supplies.

Clarice Coyne is currently collaborating on several soft-funded projects including as Co-PD on USDA AFRI SCRI CAP project “Building a Better Lentil from the Ground Up” \$3.1 M, \$512,000 to WSU (2018-2022) that covers postdoctoral research salaries and wages for

CY 2020 Activity Report

undergraduate research assistants. She is leading a USDA Pulse Health Crop Initiative project “MP3: More Protein, More Peas, More Profit”, which is an ARS NACA with a total of \$469,000 to WSU (2018-2023), that, covers sequencing 400 pea accessions, partial postdoctoral salary, and wages for undergraduate research assistants. She is a Co-PD on WA State Department of Agriculture Specialty Crop Block Grant \$248,000 to WSU (2020-2023) “Enhancing the competitiveness of Washington peas in a plant-based protein market” that covers one postdoctoral research salary (3 years). Co-PD on Foundation for Food and Agricultural Research project “Increasing total protein content in pea using large-scale phenotyping and targeted breeding with genomic selection” \$1.2 M to \$343,000 to WSU (2020-2023), covering one postdoctoral researcher (2 years) and undergraduate student research assistant. Lead PD on US-Israel Binational Science Foundation project “The adaptation of wild pea to water stress” \$180,000, \$90,000 to WSU (2016-2021), COVID19 extension, covered RNAseq sequencing, partial postdoctoral salary, and wages for undergraduate research assistants. Co-PD ID State Specialty Crop Block Grant project “*Pea seed-borne mosaic virus* pathotypes and host resistance alleles” \$149,000, \$40,000 to WSU (2018-2021), covered sequencing costs and undergraduate research assistants.

Research Geneticist Long-Xi Yu successfully continued to oversee several research grants in 2020 including “Marker Assisted Breeding in Elite Alfalfa Germplasm to Enhance Biomass Productivity During Drought”, a grant provided by Alforex Seeds totaling \$400,000 with \$210,000 to ARS-Prosser (2017-2022); “Bacterial Stem Blight of Alfalfa: Connection with Frost Damage, Development of Resistant Germplasm, and Mapping Resistance Genes” from NIFA-AFRP totaling \$235,311 with \$34,536 to ARS-Prosser (2017-2021) and “Genomics-Enabled Purging Selection to Develop 200 Alfalfa Inbred Lines for High Yield Hybrid Production” from NIFA-AFRP totaling \$300,000 with \$80,000 to ARS-Prosser (2018-2021); “Determining Genetic Factors that Influence Protein Quality and Yield in Alfalfa” from NIFA-AFRP totaling \$250,000 with \$100,000 to ARS Prosser (2020-2022). These grants support two Postdoctoral Research Associates working on bioinformatics, quantitative genetics, and functional genomics for development of markers and improvement of alfalfa with resistance to disease and abiotic stress.

In 2020, *Beta* Curator Barbara Hellier received funding from the Beet Sugar Development Fund (BSDF) for her project titled “*Beta* Germplasm conservation and regeneration”. The \$10,800 was used to support maintenance activities (regeneration and viability testing) of the NPGS *Beta* collection.

FACILITIES

The WRPIS currently counts on 34,800 square feet of greenhouse facilities (22,375 sq. ft. Federal, 12,425 sq. ft. Washington State University) and 157.3 acres of farmland (86.2 acres Federal, 71.1 acres WSU). WRPIS staff uses 12 laboratories (5 Federal, 7 WSU), and 22 offices (4 in Federal buildings, 6 in a Federal mobile office building, 12 in WSU buildings). Pullman facilities will be affected, starting 2022, by plans for a new USDA building on the WSU campus that will house the Unit’s laboratory and office space – *discussed below*. The ARS Alfalfa Research Geneticist and the TFL Curator have assigned office, greenhouse, and laboratory spaces at the Prosser worksite in both Federal and WSU facilities on the IAREC campus, and facilities there remained unchanged.

One of the biggest infrastructure updates to report is that USDA ARS has obligated \$104.9 M for the construction of a new Plant Biosciences building on the WSU campus (**Figure 1**). This new building will house USDA and WSU Units/Departments, faculty offices and laboratories. It will house all Pullman-based WRPIS scientific and technical staff and include six modern Unit-shared laboratory spaces. The new building will be built on what is the current Johnson Hall footprint. Johnson Hall is an aged (1961) building that has not received any substantial renovations since its construction date, is expensive to operate, and is scheduled for demolition soon. Most WRPIS scientists as well as some support staff are currently located and use laboratory space in Johnson Hall and will be temporarily reassigned to quarters on campus. The new building is scheduled to be completed in late early 2026 and WRPIS will occupy new facilities.

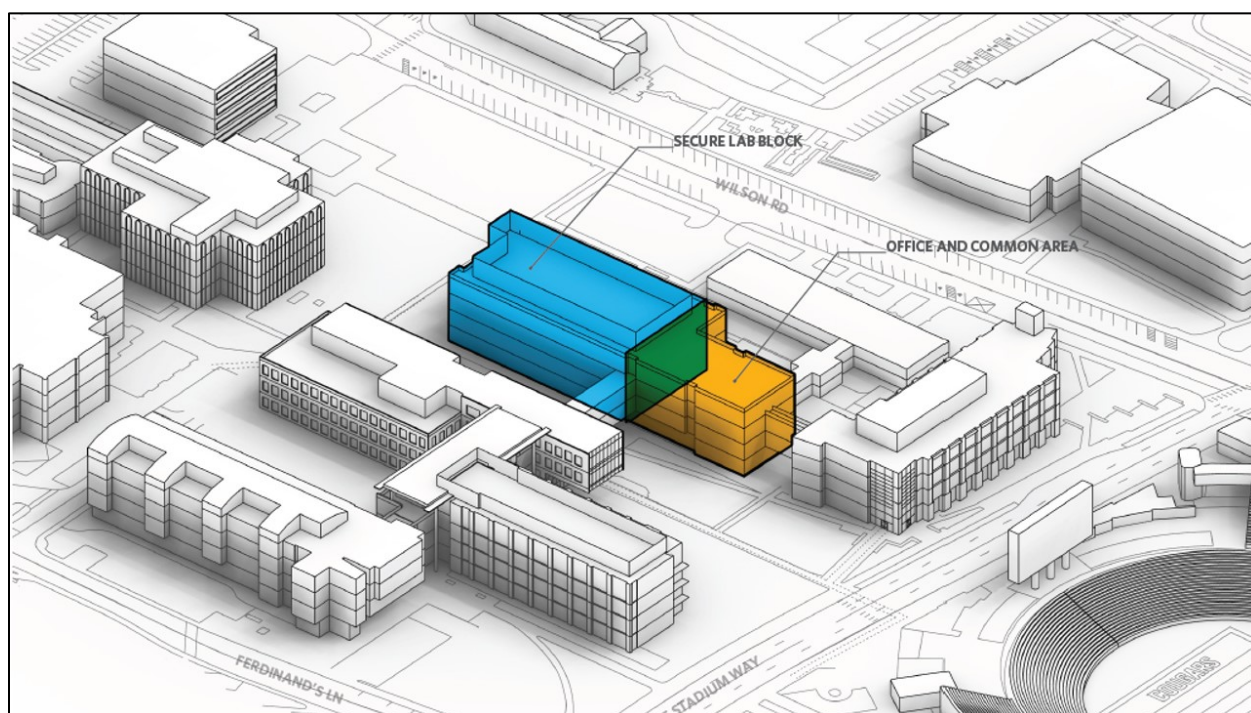


Figure 1. Proposed location and concept of the new Plant Biosciences building on WSU campus, superimposed on Johnson Hall (*to be demolished*) footprint.

After years of frequent maintenance (parts and labor), a decision has been made to replace a large Bry-Air dehumidifier unit that aids in keeping low humidity in the Station's seed storage vault. This is an older model for which no replacement parts can be procured, is no longer serviceable and has more than passed its useful life cycle. Funds for replacing the existing unit have been obligated and contractor is waiting for some final parts for work to begin. All preparations for contractor to begin work have been completed. Project should take just over a month to replace the old equipment, once work begins early summer. The costs associated to this project will approximate \$350,000.

Proper crop rotation is one of the necessary management steps to produce quality seeds for distribution to stakeholders worldwide. For this reason, WRPIS needs adequate farmland to

replace the 28.5 acres lost in 2018 due to the Pullman-Moscow Regional Airport Expansion project. This farmland was assigned to WRPIS by WSU for germplasm regeneration and research purposes. The WSU land management team has worked with Pullman Farm and Facility Manager, Saber Glass, and staff to find suitable replacement ground. In 2020 WRPIS leased 12 acres of farmable land near Palouse, WA. The cost of the land is \$100 per acre and it is located about 20 miles and a 30-minute drive from Pullman. The land is currently being conditioned for WRPIS activities and will have a first crop planted fall 2021 or spring 2022.

In Central Ferry, the new Winandy greenhouse (35' x 100'), was used for its first *Phaseolus* regenerations in Spring 2020 after all final electrical installations early in the year (**Figure 2**). Also, during the spring all grow lights arrived and were installed by electrical contractor. This new greenhouse replaced the 40-year-old wooden structure greenhouse that was also demolished with future plans to erect another greenhouse on its footprint. A refrigerated shipping container delivered in 2019 is being readied to house 23,000 Transformed (T-DNA) tagged transgenic *Brachypodium distachyon* lines generated by the Department of Energy (DOE) Feedstock Genomics Program at the Joint Genome Institute (JGI) in California. This seed will only be distributed from our site, not regenerated. The shipping container will provide additional storage space for other purposes. In 2020, electrical installations were completed, and a backup generator is soon to be connected.



Figure 2. Central Ferry facilities improvement activities. First *Phaseolus* crop in the Winandy greenhouse, spring 2020 (left); demolition of 40-year old wooden greenhouse (middle); and the Carrier-PrimeLINE® refrigerated container at the Central Ferry Farm (right).

GERMPLASM MANAGEMENT

The five curatorial programs at WRPIS manage the diverse crop species assigned to the Station by the National Plant Germplasm System (NPGS). These crop species are divided roughly into ten groups: 1) forage and turf grasses; 2) cool season food legumes (pea, lentil, chickpea, faba bean, lupin, etc.); 3) temperate-adapted forage legume crops (alfalfa, clover and trefoil); 4)

beans; 5) lettuce; 6) safflower; 7) garlic; wild onion and onion relatives; 8) sugar beet; 9) select ornamentals; and 10) medicinal and miscellaneous plant species. **Figure 3** shows the number of accessions for major crop groups/crops maintained at WRPIS. The WRPIS ranks second among four regional Plant Introduction (PI) stations and third among 28 NPGS sites and collections in terms of number of accessions managed (<https://www.ars-grin.gov/Pages/Collections>). At the time of this report's preparation, there were 99,877 accessions in the WRPIS collections. This was approximately 17% of the total NPGS accession holdings (600,283). When diversity in the collections is considered, WRPIS ranks first with the highest number of genera (954; ~37%) and taxa (4,988; ~31%) in the NPGS. Most WRPIS accessions are maintained as seed, with a small proportion of vegetatively propagated accessions (e.g., garlic, wild onion, rhubarb and a few vegetables, grasses, and ornamentals).

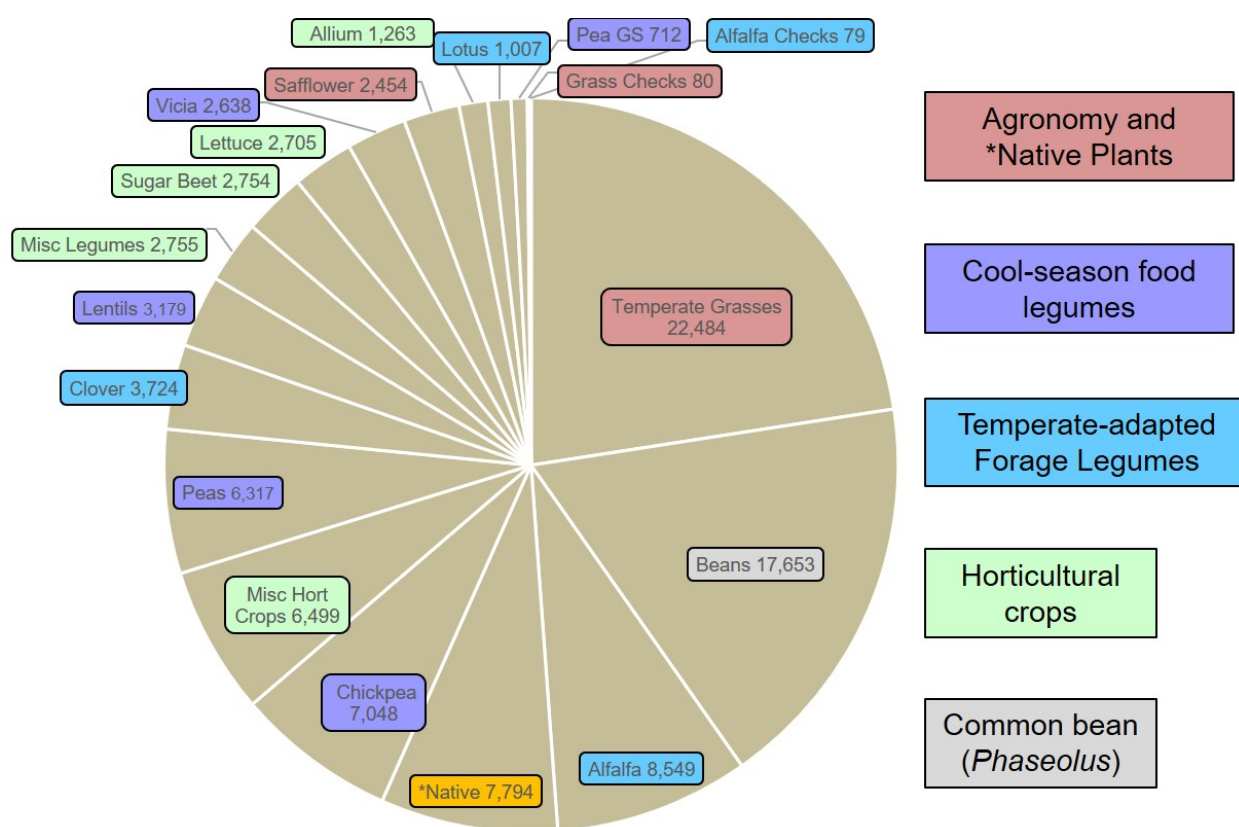


Figure 3. The five curatorial programs and assigned major crop groups at WRPIS.

The **Agronomy and Native Plants Program** (Vacant) manages 32,813 accessions of cool season turf and forage grasses, safflower and the native plant accessions collected in recent years by the Bureau of Land Management (BLM) Seeds of Success (SOS) project. The **Cool Season Food Legumes Program** (Clarice Coyne) curates a total of 22,649 accessions of pea, chickpea, lentil, faba bean, and other legumes. The ***Phaseolus*/Beans Program** (Vacant) manages a collection of 17,653 accessions, all belonging to the *Phaseolus* genus. The **Temperate-adapted**

Forage Legumes Program (Brian Irish) manages alfalfa, clover, trefoil, and their wild relatives with a total of 13,359 accessions. The **Horticultural Crops Program** (Barbara Hellier) manages 13,221 accessions of sugar beet, lettuce, garlic, and many miscellaneous species that have potential use for ornamental or medicinal purposes. Due to accruing vacancies, curatorial program duties for the *Phaseolus*, **Agronomy** and **Native plants** programs have been reassigned temporarily to Barbara Hellier, Clarice Coyne and Brian Irish, respectively.

Although not directly related to germplasm management, in 2020 WRPIS curatorial and technical staff worked with USDA ARS National Program 301 Leader Peter Bretting on compiling detailed information required for a congressionally mandated Farm Bill NPGS plan. The plan is close to being completed for the Secretary to present to Congress. The plan was to assess, by NPGS sites and genebanks, current status and outline future needs in order to effectively meet their missions. To effectively meet its mission, WRPIS will need significant infrastructure investments (additions and modernizations) as well as significant additions to curatorial and administrative personnel.

Acquisition

During the 2020 calendar year, there were 883 new accessions added to the WRPIS collections including 766 native plant accessions from the SOS project. An additional 102 *Pisum fulvum* accessions were collected and donated by Shahal Abbo from wild habitats in Israel. Seven *Lactuca sativa* breeding lines (RH16-0001, RH16-0002, RH16-0003, RH16-0004, RH16-0005, RH16-0007, RH16-0008) were added to collections as germplasm with improved resistance to lettuce drop. Also, six new *Phaseolus vulgaris* cultivars from breeders at the University of California were also added and include “UC Four Corners Red”, “UC Southwest Gold”, “UC Rio Zape”, “UC Tiger’s Eye” and “UC Sunrise”. A unique *Medicago truncatula* accession, was received as "*Medicago truncatula* subsp. *tricycla*" which was used by the Noble Research Institute for transformation to produce *Tnt1* mutant lines was added. Lastly, a single split Journal of Plant Registrations sample of *Phaseolus accutifolius* from Fort Collins was included.

The total number of accessions held at the end of each calendar year over the past ten years is shown in **Figure 4**. The noticeable drop in Station accession holding was mostly due to the transfer of close to 1,500 SOS native accessions to other NPGS priority sites in 2019. The value of these agriculturally important additions to the WRPIS collections continues to grow as international access to germplasm is increasingly limited by the changing political environments.

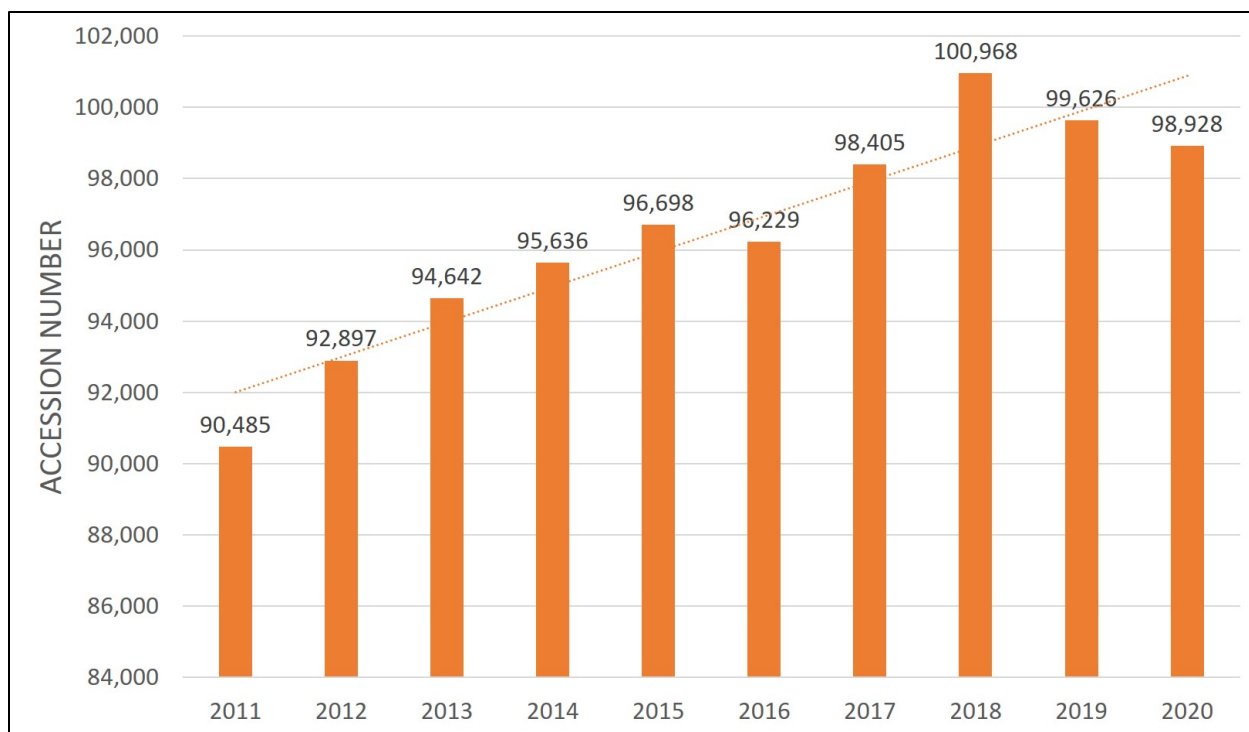


Figure 4. Total number of accessions managed by WRPIS since 2011 (numbers recorded at the end of each calendar year).

Conservation

In 2020, WRPIS was scheduled to regenerate 2,344 inventories by following the established, labor-intensive procedures and protocols for maintaining the genetic integrity and health of all germplasm collections. These included physical isolation, hand planting and transplanting, controlled hand and insect pollination, hand harvesting, cleaning, and packaging for storage and distribution.

A total of 813 seed viability records were entered into the GRIN-Global database. Of these, 58 inventories were tested in-house by the Horticultural Crops curatorial program and other seed testing personnel with NLGRP in Fort Collins, CO contributing 755 tests. For security backup, 1,270 inventories were sent to NLGRP at Fort Collins, CO in 2020. No inventories were sent to the Svalbard Global Seed Vault, Longyearbyen, Svalbard, Norway in 2020 due to Pandemic related issues.

Characterization/evaluation

A total of 456 observation data points on 456 accessions were uploaded into the Germplasm Resources Information Network (GRIN)-Global database. These data points were for eight established descriptors of three different crops. Collaborators contributed 3% and WRPIS staff provided 97% of the evaluation data. In addition, 2,651 voucher images (2,612 seed/39 plant) were uploaded to GRIN-Global with most of them being seed, flower, and leaf images. This information can be accessed by researchers worldwide via GRIN-Global and the internet.

A survey for resistance to *Fusarium proliferatum* in the WRPIS *Allium sativum* and *A. longicuspis* germplasm collections has been completed for close to 100 accessions. Of the accessions screened, 15 were found to be pathogen-free and were then subjected to *in vitro* challenge in a replicated and repeated study. Individual cloves were examined for symptoms and plated to agar for evaluation of infection by the pathogen compared to sterile water mock-inoculated controls. None of the accessions tested showed resistance to the disease at what would be considered low inoculum levels for a challenge study.

With funding from U.S. Alfalfa Farmer Research Initiative (e.g., Alfalfa Check-off), Brian Irish and team have completed screening a large and diverse set of alfalfa and wild relative germplasm for disease reaction to *Phoma medicaginis*, the causal organism for spring black stem (SBS) and leaf spot of alfalfa. By the end of 2020, the project had completed all objectives relating to SBS. Close to 3,000 alfalfa accessions and its wild relatives were evaluated in greenhouse assays. The research 1) produced improved inoculation and scoring procedures; 2) more clearly defined host range within the *Medicago* genus; and 3) produced resistant selections for initial crosses of improved pre-bred populations. All accession-associated data will be uploaded to GRIN-Global.

Cool Season Food Legume Curator Clarice Coyne participated in a collaborative project on “Dissecting genetic architecture of *Aphanomyces* root rot (ARR) resistance in lentil by Quantitative Trait Loci (QTL) mapping and genome-wide association” using the USDA Lentil Core Collection and SNP genotyping (**Cover photo**). This is the first report of genetic resistance in cultivated lentil. Seven QTL clusters were discovered on six chromosomes by QTL mapping and Genome-wide associated studies (GWAS). Genes involved in secondary metabolism and cell wall modification are potentially associated with *Aphanomyces* root rot resistance (ARR). Our findings provide valuable insight into the genetic control of ARR and genetic and genomic resources developed here can be used to accelerate development of lentil cultivars with high levels of partial resistance to ARR.

Distribution

Figure 5 shows the annual number of orders and order items (e.g., seed packets, garlic bulbs, rhubarb crown pieces ...) distributed for each of the past ten years. In 2020, the order number (975) and the unique requesters distributed to (577) were down, however the number of items distributed held steady (36,790) when compared to other years. This apparent change in distributions is due to the more stringent order approval process implemented by curatorial programs to avoid filling non-research requests. Increased capabilities for genotyping and high-throughput phenotyping may have also led to larger individual item requests by researchers. Distributing 36,790 order items in 2020 was a monumental task and shows interest in the user community for germplasm held by the WRPIS. Among the distributed packets, 76%, or 28,092 packets, were sent to addresses covering 47 U.S. domestic states and 24%, or 8,878 packets, were sent to requesters in 28 countries outside the U.S.

The most requested plant group at WRPIS were cool season food legumes (13,332 packets). The increase in distributions from this group reflects increases into research on plant-based proteins for human consumption. Other groups with high demand included germplasm distributed from the horticultural crops program (7,272 packets), followed by *Phaseolus*/bean (5,366 packets), the cool season grasses (4,863 packets), temperate-adapted forage legumes (4,591 packets), and native plants (568 packets).

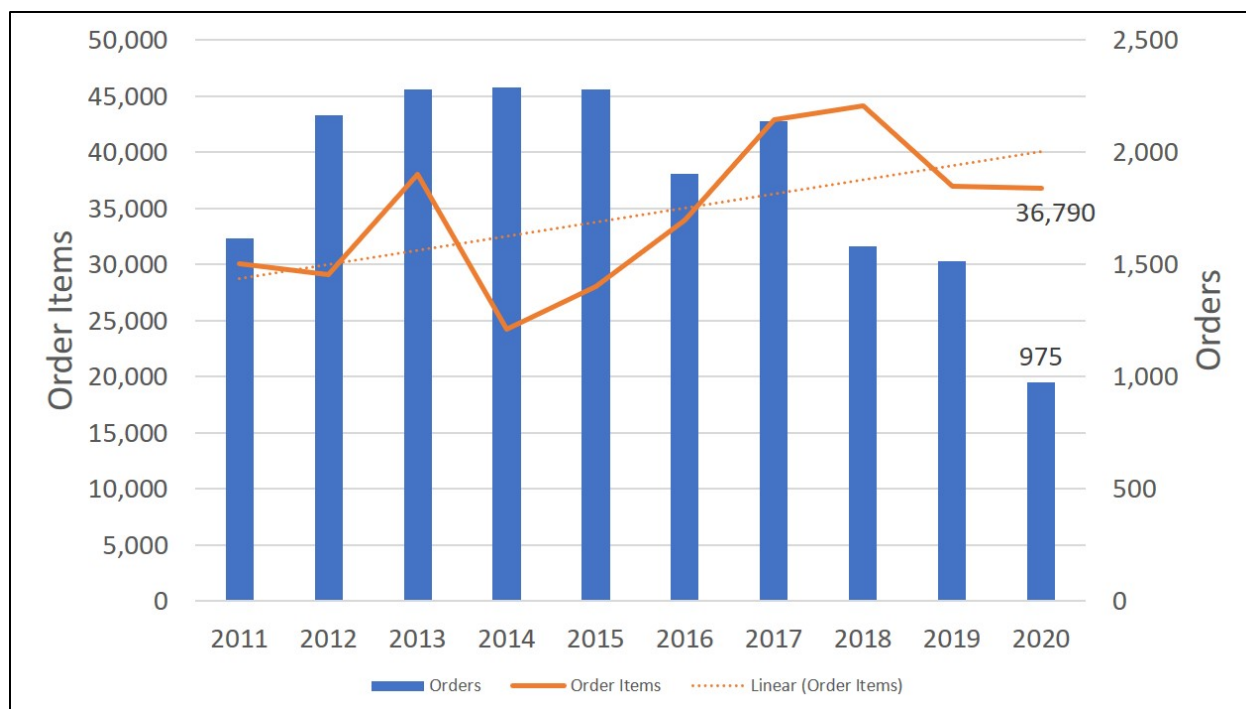


Figure 5. Number of orders and order items distributed annually by WRPIS from 2011 to 2020. *(e.g., - seed packets, garlic cloves, ...).

Utilization - Western States

According to data generated by Lisa Taylor, WRPIS Seed Storage and Database Manager, germplasm users in the 13 Western states (AK, AZ, CA, CO, HI, ID, MT, NV, NM, OR, UT, WA, and WY) received 25,122 from all nationwide NPGS genebanks in 2020. A total of 5,508 packets were distributed by WRPIS to these western states. This means that on average 15.0% of the samples received by users in these 13 Western states was distributed by WRPIS. These genetic resources from NPGS were used for research and education in diverse scientific disciplines and contributed to scholastic and economic activity in this agriculturally important region of the United States.

Table 1 below provides the numbers of order items distributed in 2020 to each of the 13 Western states by WRPIS and NPGS, respectively. The number of items received from WRPIS by each state varied from 1 (Alaska) to 3,726 (Washington). From the NPGS, the item distributions to the 13 Western states ranged from 79 (Alaska) to 9,388 (Washington). Washington, Colorado, and California were the top three states in terms of receiving germplasm from WRPIS in 2020. Distributions to the state of Washington were increased in part due to large in-house characterizations and evaluations (e.g., alfalfa disease reaction screening).

Table 1. Numbers of plant germplasm order items (e.g., seed, or clonal propagules) distributed in 2020 to each of the 13 Western States by the NPGS and the WRPIS.

State	WRPIS	NPGS	WRPIS %
Alaska	1	79	1.3
Arizona	154	2580	6.0
California	433	5748	7.5
Colorado	661	2270	29.1
Hawaii	42	167	25.1
Idaho	110	1683	6.5
Montana	37	712	5.2
Nevada	24	331	7.3
New Mexico	12	263	4.6
Oregon	206	1276	16.1
Utah	39	424	9.2
Washington	3,726	9,388	39.7
Wyoming	63	201	31.3
Total	5,508	25,122	15.0

*Data provided by Lisa Taylor

CURATORIAL PROGRAM SUMMARIES

1. Agronomy (Cool season grasses and Safflower) Program

Curator: Vacant (June 2018). Acting Curator - Clarice Coyne

Technician: Bob Guenther (full-time)

The program was extended to include the native plants program after the retirement of the Agronomy Research Scientist, Richard 'RC' Johnson in 2016. It includes the collections of cool season grasses, safflower, and native plants. As the Agronomy and Safflower program Curator position is vacant, the Native portion of this program is being overseen by Brian Irish.

- A. **Cool season grasses** – 124 second year grass accessions were harvested in 2020. The goal of the Acting Curator was to build the program back up after a hiatus of the project in 2018. 305 grass accessions were selected and planted in 2020 for regeneration considering quality, viability, and quantity of seed, and isolation requirements (**Figure 6**). Seed orders of 309 grasses has been set up for germination and transplanting in 2021. Of these, 25 accessions required special germination techniques such as scarification, stratification, or germinating in the dark.
- B. **Safflower** – The safflower collection of 2,454 accessions is in excellent condition. The collection is 97% backed up at NLGRP and 96% of the accessions are available for distribution. 12 accessions were regenerated in 2020. Acting Curator has obtained an USDA APHIS Noxious Weed permit, so the WPRIS is now able to ship the safflower noxious weed accessions to researchers.



Figure 6. Agronomy program regeneration activities. Grass transplants hardening off in shadehouse prior to transplant (left), and grass accession plugs being established in field using mechanical transplanter (right).

2. Cool Season Food Legumes Program

Curator: Clarice Coyne (full-time)

Technician: Britton Bourland (full-time)

Postdoctoral Research Associate: Yu Ma (Supported by grants from the USA Dry Pea and Lentil Council and the Northern Pulse Growers Association)

This program manages the germplasm of all cool season food legumes including pea, chickpea, lentil, faba bean and numerous *Lathyrus* and *Vicia* legume species with usage other than food. We grew 1,047 accessions for regeneration of low quantity or low germination or for security backup. A total of 60 and 98 pea accessions were regenerated on the WSU campus in our greenhouse and insect-proof two-season shadehouses, respectively. 540 pea, 73 lentil, 22 *Vicia sativa*, 7 fenugreek, 17 *Lathyrus sativus* accessions were direct seeded for regeneration in Pullman and 124 chickpeas were regenerated at Central Ferry farm (**Figure 7**). The 32 faba bean accessions regenerated in 2020 were grown with protection from cross-pollination contamination using screened caging. For regeneration of 39 annual *Lupinus* accessions 4,536 transplants were produced, also protected from cross contamination (**Figure 7**). Included in 2020 were 44 accessions of wild *Cicer reticulatum*, a wild relative of cultivated chickpea that can be used in breeding, which were newly collected and donated from Turkey. 538 accessions were sent to NLGRP for security backup.



Figure 7. Cool season food legume regenerations. 2020 chickpea regeneration plots in Central Ferry (left); and transplanting annual lupins on the Pullman farm in 2020 (right).

- A. Lentil production is increasing in acreage in the U.S. with expanding domestic and export markets. Clarice Coyne cooperated on a project “Understanding the photothermal interactions will help expand production range and increase genetic diversity of lentil (*Lens culinaris* Medik.)”. The research involved 430 accessions and cultivars of domesticated lentil which were genotyped using exome capture with 39,297 single nucleotide polymorphism (SNP) markers. Future climate change scenarios will result in increased temperatures and

shifts in lentil crop production areas, necessitating expanded breeding efforts. We show how a day length and temperature model can be used to identify varieties most likely to succeed in these new environments, expand genetic diversity, and give plant breeders additional knowledge and tools to help mitigate these changes for lentil producers.

3. Temperate-adapted Forage Legume & Native Plants Programs

Curator: Brian M. Irish (full-time)

Technician: Estella Cervantes (full-time)

Support Horticulturist: Mike Cashman (full-time)

WSU Farmer: Jesus ‘Jesse’ Prieto (full-time)

Cooperator: Elizabeth Martin (native plants)

The Temperate-adapted Forage Legume (TFL) genetic resources program is an important component of the WRPIS in Pullman, WA and operates at the USDA ARS worksite in Prosser, WA. The project focuses on acquiring, maintaining, characterizing, evaluating, and distributing alfalfa, clover, trefoil, and wild relative germplasm accessions as well as database-maintaining all associated documentation. Since 2019, Curator Brian Irish has been leading the Native Plants program and its Seeds of Success collaboration. **Figure 8** shows a two-sided factsheet summarizing the Seeds of Success collaborative project activities developed as a handout while hosting visitors.

- A. During the 2020 CY a U.S. Alfalfa Farmer Initiative (USAFRI) funded project entitled “Spring black stem and Stemphylium leaf spot resistance screening in the USDA ARS National Plant Germplasm System’s *Medicago* sp. genetic resources” was completed. Spring black stem (SBS) and Stemphylium leaf spot (SLS), caused by *Phoma medicaginis* and *Stemphylium* sp., respectively, are important alfalfa foliar fungal plant pathogens for which good disease resistance is not available in commercial varieties. By the end of 2020, the project had completed all objectives relating to SBS. The project screened close to 3,000 alfalfa accessions and its wild relatives in greenhouse assays. The research produced 1) improved inoculation and scoring procedures; 2) more clearly defined host range within the *Medicago* genus; and 3) made resistant selections for initial crosses of improved pre-bred populations.
- B. For the 2020 growing season a total of 160 plots were scheduled for regeneration including 51 *Medicago* species, 86 *Trifolium* species and 19 *Lotus* accessions. In addition to the germplasm accessions to be increased, 14 plots of the ‘Vernal’ alfalfa variety were established, and seed harvested from both covered (with insect proof cages) and uncovered sentinel plots. Of the plots being increased in 2020, 35 were carried over from previous plantings due to insufficient seed regenerated in prior years. Phenotypic traits for many accessions regenerated during the year were collected and captured by scanning and generating voucher images for flowers, pods, and seed. All threshed and chalcid-free seed from 2019 increases was submitted to the Pullman-farm crew to be further cleaned. All passport and associated information and voucher images were provided to technical personnel for loading into the Germplasm Resource Information Network (GRIN) Global database.

CY 2020 Activity Report

- C. For the 2020 calendar year a total of 4,998 alfalfa, clover, trefoil, and their crop wild relative accessions were distributed in 90 orders to 71 unique cooperators. Just over 13% of the order requests, and subsequent shipments, were from/to international cooperators.
- D. In the Native Plants Program, we continued to collaborate with Bureau of Land Management (BLM) to manage the native plant seeds collected by the SOS program from public lands in the U.S. In 2020 the project has refocused time to quality assessing historical passport data and improvement of queryable passport information included in GRIN-Global. A detailed comparison of data received from SOS partners in BG-Base exports into Excel are being compared to existing data in GRIN-Global. Where mistakes in matching unique identifying information in the two datasets are found, these are being corrected. In addition, passport information previously not included in GRIN-Global, like Ecoregion, Slope, Aspect, and Landowner are now being populated into Source Habitat Fields now available in GRIN-Global. This increased information, available to NPGS curatorial staff currently, will aid in germplasm management decisions. The data will eventually be public facing information for stakeholders to aid in selecting germplasm for their research.
- E. The Native Plant Program also began efforts in 2020 to assess optimized seed germination assays to identify effects of different stratification regimes on breaking seed dormancy in native *Astragalus* (milkvetch) species accessions. Ten accession belonging to five species (*A. bisulcatus*, *A. lonchocarpus*, *A. lentiginosus*, *A. drummondii* and *A. canadensis*) were subjected to different stratification times (0, 2 and 6 weeks) and two germination temperatures (Low: 15/25°C and High: 20/30°C). Results indicate that a 2-week stratification and cooler temperatures generally produced optimal germinations for these species.

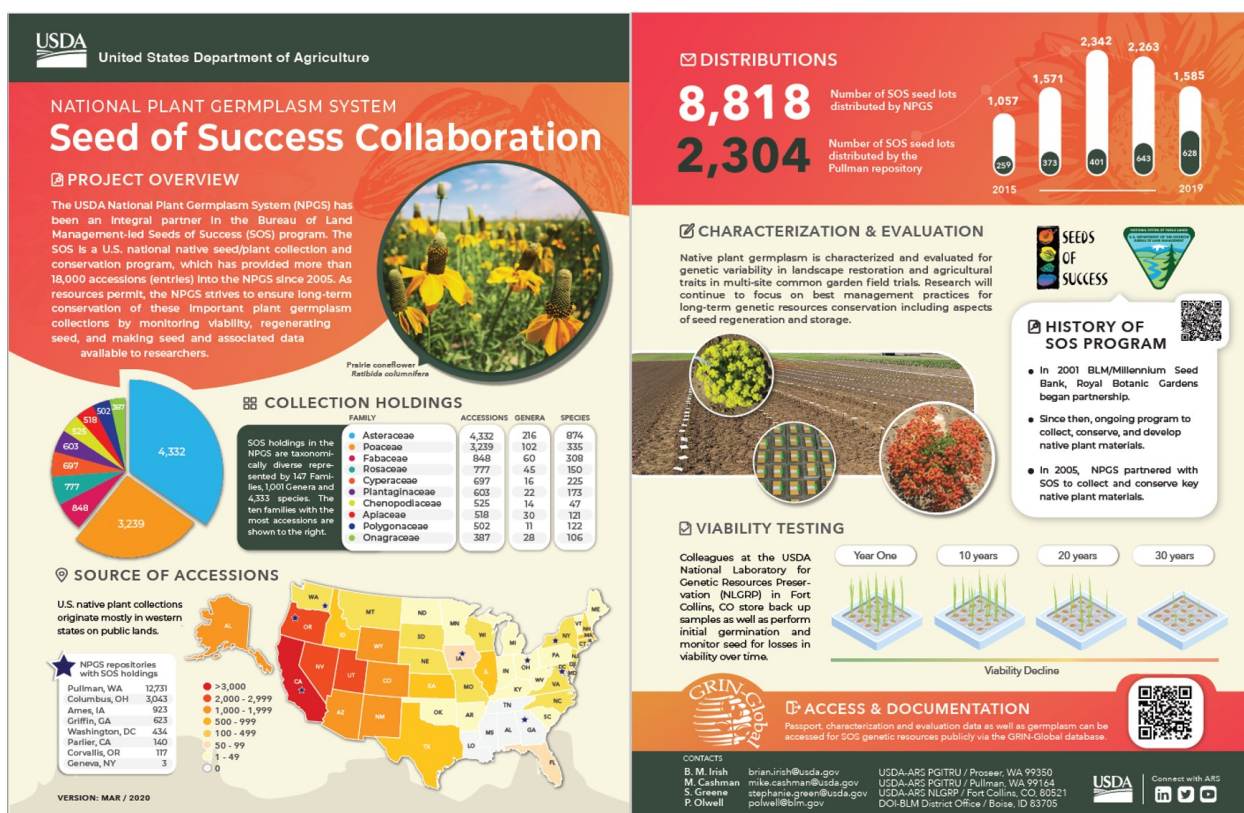


Figure 8. Two-sided factsheet/infographic summarizing research and service activities for the Seeds of Success BLM-collaborative project.

4. Horticultural Crops Program

Curator: Barbara Hellier (full-time)

Technicians: Marie Pavelka (full-time); Alex Cornwell (full-time)

The Horticulture Crops and *Beta* Program is responsible for 13,221 accessions in four maintenance groups – *Beta* (sugarbeet, table beet, chard and leaf beet, fodder beet and wild *Beta* and *Patellifolia* species), *Allium* (garlic leeks, chives and all wild *Allium*), Lettuce (cultivated lettuce and wild *Lactuca* and related genera) and Miscellaneous (minor forage legumes, industrial crops, current and potential ornamental species, medicinal and culinary herbs, rhubarb, and restoration and revegetation species). These collections comprise most of the generic diversity held at W6 outside of the SOS program.

- A. In 2020 we focused on regeneration and maintenance activities. We established new regeneration nurseries with 30 accessions in the Miscellaneous maintenance group and 6 *Allium*. We harvested seed of 59 established accessions. We increased 71 *Lactuca sativa* accessions in the field and 13 *L. serriola* accessions in the greenhouse. We harvested 29 accessions of *Beta* and started 14 accessions for regeneration. For all our regeneration plots we take images (**Figure 9**) and for the Miscellaneous accession we also collect herbarium samples.



Figure 9. Plot or plant images (upper left clockwise) for W6 20288, *Onobrychis arenaria*, W6 45860, *Beta maritima*, W6 1893, *Allium jodanthum*, PI 578885, and *Lactuca sativa*, PI 578885.

- B. In addition to the activities relating to seed producing germplasm accessions, we maintained the *Allium* and rhubarb clonal collections (363 accessions). We do all the cleaning and preparation work for distribution of these collections. In 2020, we only filled 2 garlic requests with no rhubarb requests filled because of the Pandemic and shutdowns.
- C. In 2020, several of the Crop Vulnerability Statements (CVS) that fall under the purview of the Horticultural Crops curatorial program were either updated or completed. Newly completed CVS for both the New Crops and Herbaceous Ornamental were submitted. We also made minor updates to the Leafy Vegetable CVS.

5. *Phaseolus*/Bean Program

Curator: Vacant (August 2019). Acting Curator - Barbara Hellier

Technician: Dawn Tachell (full-time)

Postdoctoral Research Associate: Lyle Wallace (full-time)

The *Phaseolus* Beans Program manages a collection of 17,653 accessions in 56 taxa, all in the genus *Phaseolus*. It is the largest single genus collection at WRPIS.

- A. In 2020 the *Phaseolus* Program primarily focused on regeneration and documentation activities. We harvested seed from 300 accessions and collected characterization data for 22 descriptors from these accessions. We also collected flower, pod, leaf, plant, and seed voucher images for our regenerated accessions (**Figure 10**).



Figure 10. *Phaseolus* spp. accession documentation images for flowers, seed, and growth habit.

- B. All the *Phaseolus* regenerations are done in the greenhouse to prevent the spread of Bean Common Mosaic virus within and among the accessions. Prior to 2019, we had 2 greenhouses in Pullman and one at Central Ferry for *Phaseolus* regeneration. This year we were able to plant the first crop in the new Winandy greenhouse at Central Ferry. Everything

worked well, with only minor troubleshooting. This new greenhouse in Central Ferry is a valuable addition to the Unit and to the *Phaseolus* Program, especially for regenerating the day-length sensitive accessions.

- C. Ted Kisha, retired *Phaseolus* curator, made several trips to collect the North American wild kidney bean, *P. polystachios*, across the range of this species but some areas remain uncollected or under collected. Postdoctoral Research Associate, Lyle Wallace, developed and submitted a plant exploration and collecting proposal for competitive funding to the NPGS Plant Exchange Office. The proposal was funded and aims to collect in central Florida and Georgia, which includes the most diverse part of the species range. These collections will fill gaps in the NPGS coverage of this important North American crop wild relative.
- D. In addition, and in conjunction with the *Phaseolus* Crop Germplasm Committee (CGC) members, *Phaseolus* CVS were substantially updated.

MISSION-RELATED RESEARCH PROGRAMS

1. Alfalfa Genetics Program

Research Geneticist: Long-Xi Yu (full time)

Technicians: Martha Rivera (full time)

Postdoctoral Research Associate: Cesar Medina Culma (Supported by grants from USDA-NIFA AFRP program and a collaboration project with Alforex and New Mexico State University); Sen Lin (Supported by USDA NIFA AFRP program)

This project focuses on enhancing resistance to biotic and abiotic stresses in alfalfa, including developing molecular markers and germplasm for breeding alfalfa varieties with improved resistance to these stressors.

- A. Verticillium wilt (VW) of alfalfa is a devastating disease and causes forage yield reductions of up to 50% in the northern United States and Canada. Current breeding strategies rely greatly on phenotypic recurrent selection that is time consuming and labor costly. In collaboration with commercial alfalfa seed companies, the team led by Long-Xi Yu in Prosser, WA mapped genetic loci associated with VW resistance in a biparental population and identified two candidate genes for disease resistance. Sequencing of the candidate genes showed variants between resistance and susceptible parents. These variants were then used to develop several PCR and kompetitive allele specific PCR (KASP) markers for VW resistance (**Figure 11**). Alfalfa seed companies are interested in using these markers to test the VW resistance alleles in their breeding programs. A material transfer agreement has been signed between ARS and S&W Seed Company to deliver these markers to the company for testing VW resistance in their breeding populations.
- B. Drought and high salinity are two abiotic stressors affecting alfalfa production worldwide. Enhancing alfalfa resistance to drought and high salinity is important to meet the challenges of limited water resources and highly saline soils. In collaboration with ARS and university scientists, a team led by Long-Xi Yu in Prosser, WA developed a nested association mapping population by crossing an elite variety with 15 drought resistance parents. This populations contain more than 1,000 individuals that are being evaluated for drought resistance in the field. The population will be used for mapping genes for drought and salt resistance. The team also identified 27 SNP markers and putative candidate genes associated with salt

tolerance in another breeding population. Genomic selection (GS) was conducted to predict breeding values for salt tolerance. This work identified the most accurate GS model that alfalfa breeders can use to predict breeding values for salt tolerance.

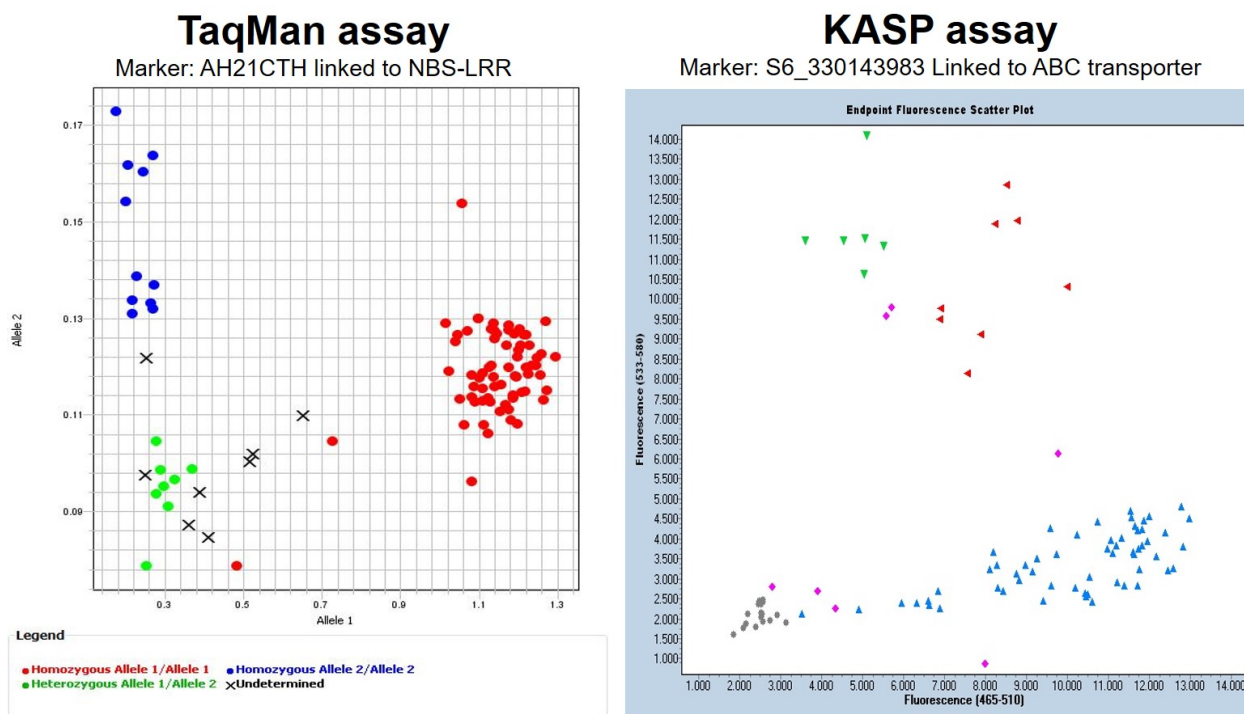


Figure 11. Molecular markers associated with *Verticillium* wilt resistance in alfalfa have been identified and validated by high-throughput assays (TaqMan left, KASP right).

2. Plant Pathology Program

Research Plant Pathologist: Vacant (October 2018)

Technician: Shari Lupien (full-time) – prepared report

The Plant Pathology Research Program encompasses all aspects of plant pathology pertinent to plant species (native and introduced) in the National Plant Germplasm System (NPGS), with emphasis on diseases and symbioses of fungal etiology pertinent to germplasm at WRPIS.

- A. Traditional vegetative field propagation of garlic continuously exposes the germplasm to seed, soil, and vector-borne pathogens. This situation combined with the need to plant each accession to the field each year to keep the collection viable can cause a high incidence of pathogens in the garlic germplasm. Utilization of the basal stem disk as the explant for *in vitro* propagation of garlic can increase the rate of pathogen-free plantlets compared to standard shoot tip culture (**Figure 12** - left). When *in vitro* bulblets are formed in culture, this allows for the logistical separation of the tissue culture process from plant propagation. The Plant Pathology Program has used this tissue culture technique to successfully form *in vitro* bulblets on a small number of garlic accessions. Plans are to test the storage of bulblets, propagate plants from bulblets, and develop Real Time PCR assays to test for the presence of known garlic viruses and fungal pathogens.

- B. The fungal pathogen *Fusarium proliferatum* is a storage pathogen causing bulb rot in *Allium* spp. worldwide. Infected garlic bulbs are frequently asymptomatic at harvest and when initially put in storage. The pathogen is recognized as a major constraint in *Allium* production. The pathogen is present in the WRPIS collection and can be potentially spread when distributing germplasm. A portion of the garlic collection has been screened for the presence of the pathogen and for potential sources of resistance to this disease (**Figure 12** - right). Five bulbs each of one hundred randomly chosen accessions were plated to agar to determine if *F. proliferatum* was present in the clove tissue. Fifteen accessions were found to be pathogen-free and were then subjected to *in vitro* challenge with the pathogen in a replicated and repeated study. The screen was conducted exposing individual cloves to 1×10^3 cells/ml prepared inoculum of two pathogenic strains or sterile water controls for two hours, followed by incubating dry cloves for four weeks at 21° C. Individual cloves were examined for symptoms and plated to agar for evaluation of infection by the pathogen compared to sterile water mock-inoculated controls. None of the accessions tested showed resistance to the disease at what would be considered low inoculum levels for a challenge study.

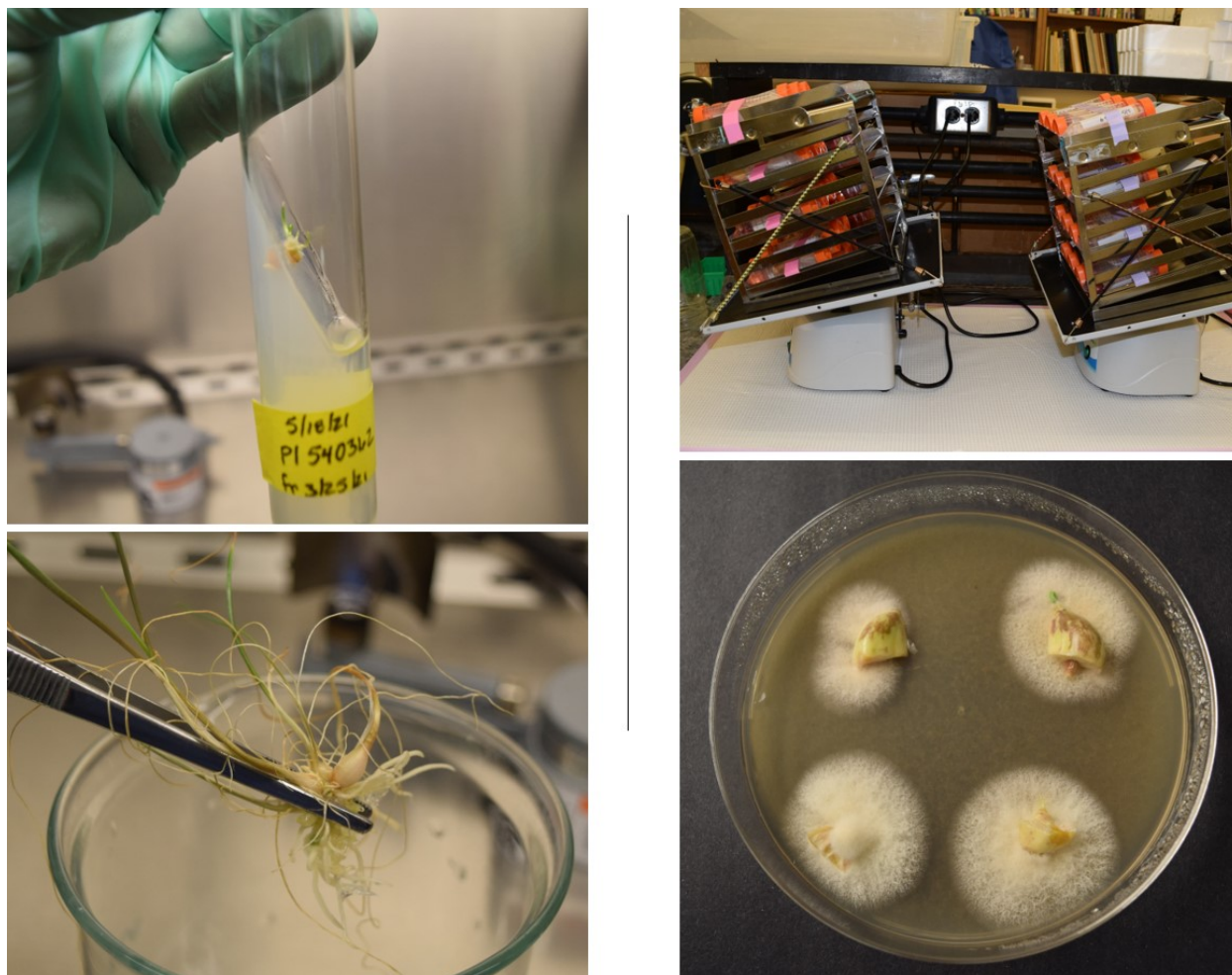


Figure 12. Garlic (*Allium sativum*) micropropagation from basal stem disk as explants (left); and *Fusarium proliferatum* germplasm inoculation and screening approaches (right).

3. Pulse Genetics Program

Supervisory Research Geneticist: Vacant (April 2020)

Technician: Vacant (March 2019)

The Pulse Genetics Research Program conducts laboratory and field research with the objective of identifying, enhancing and developing desirable germplasm lines with enhanced productivity and end-use quality of faba bean (*Vicia faba* L.) and other pulse crops to meet the need of the export-driven, expanding U.S. pulse industry.

*This program was led by Jinguo Hu (retired in April 2020) with limited activity to report.

COMMITTEES, PRESENTATION AND SERVICE

During 2020 WRPIS scientists and curators served as *ex officio* committee members or chairs of their respective national Crop Germplasm Committees (CGC) and other academic or social organizations. Research Geneticist **Long-Xi Yu** is adjunct faculty with WSU Department of Crop and Soil Sciences. He serves as member of The AOSCA National Alfalfa and Miscellaneous Legumes Variety Review Board and Washington State Hay Growers Association. He also serves as Editor-in-chief of the International Journal of Plant Pathology and Plant Protection and member of the editorial board of eight peer-reviewed journals. Cool Season Food Legumes Curator **Clarice Coyne** is an Adjunct faculty in WSU Departments of Horticulture and Crop and Soil Sciences and a member of the Graduate School faculty. Clarice Coyne was elected as a Fellow of the American Association for the Advancement of Science (AAAS) in 2020. She co-supervised two Postdoctoral Research Associates at WSU and is serving *ex officio* on three CGCs including *Pisum*, Food Legume, and Forage Legume CGC. She serves on the Scientific Advisory Board for a University of Saskatchewan pea project in Saskatoon, Canada. Besides AAAS, Clarice Coyne is a member of the American Society of Agronomy, Crop Science Society of America, and the North American Pulse Improvement Association. She serves on the Crop Science Editorial Board and as Crop Science Society of America (CSSA) Technical Editor, Div. C-1, C-8. She served as a peer-reviewer for the journals Physiological and Molecular Plant Pathology, Legume Science, Frontiers in Plant Science, Crop Science Journal and Agronomy. Temperate-adapted Forage Legume Curator **Brian Irish** is *ex officio* member of the Forage Legume CGC and is the current Chair of the Plant Germplasm Operations Committee (PGOC) of the NPGS. He is also a member of the Federal Implementation Working Group and Research Subgroup on efforts relating to the execution of the National Seed Strategy for Rehabilitation and Restoration. Brian Irish is also actively involved in a Cornell-led and USDA funded Breeding Insight efforts to leverage recent improvements in genomics and open source informatics components to accelerate their genetic gains in alfalfa. He is also part of a working group leading efforts to develop and draft a Global Strategy for the *ex situ* Conservation of Temperate Forages. He is an adjunct faculty member with WSU Department of Crop and Soil Sciences and a member of the CSSA and American Phytopathological Society. Horticultural Crops Curator **Barbara Hellier** is an *ex-officio* member of numerous CGCs including Root and Bulb, Leafy Vegetable, New Crops, Sugarbeet, Forage Legume, and Medicinal and Aromatic Oil and Herbaceous Ornamental Crops. She is also a member of the PGOC Plant Exploration

subcommittee. She is a member of the American Society for Horticultural Science and the American Society of Sugarbeet Technologists.

In 2020, WRPIS scientists and curators were actively engaged in conducting mission-related research and serving the scientific community. Activities for 2020 were less than during a typical year due to vacancies in key positions (e.g., Research Leader) and the COVID-19 Pandemic affecting travel and many professional society meetings. Despite the circumstances, personnel made a total of 15 oral or poster presentations at either scientific or public meetings and were involved in 11 peer reviewed scientific journal publications. They were invited to review research proposals by funding agencies such as NIFA and participated as subject matter experts and in many *ad hoc* peer-reviews of manuscripts in scientific journals.

PUBLICATIONS – 2020

Peer reviewed (11)

- Agarwal, C., W. Chen, C.J. Coyne, and G. Vandemark. 2020. Identifying sources of resistance in chickpea to seed rot and seedling damping-off caused by metalaxyl-resistant *Pythium ultimum*. Crop Science <https://doi.org/10.1002/csc2.20424>
- Coyne C.J., S. Kumar, E.B. von Wettberg, E. Marques, J.D. Berger, R.J. Redden, N.T.H. Ellis, J. Brus, L. Zablatzka and P. Smýkal. 2020. Potential and limits of exploitation of crop wild relatives for pea, lentil, and chickpea improvement. Legume Science 36. doi.org/10.1002/leg3.36
- He F, Long R, Zhang T, Zhang F, Wang Z, Yang X, Jiang X, Yang C, Zhi X, Li M, Yu L-X, Kang J, Yang Q. 2020. Quantitative trait locus mapping of yield and plant height in autotetraploid alfalfa (*Medicago sativa* L.) The Crop J. 812-818. <https://doi.org/10.1016/j.cj.2020.05.003>
- Hellwig T. Abbo S., Sherman A., Coyne C., Saranga Y., Lev-Yadun S., Main D., Zheng P., Ophir R. 2020. Limited differential environmental adaptation as a result of a severe bottleneck in *Pisum fulvum*, a wild relative of domesticated pea. Molecular Ecology 29(22):4322-4336. <https://doi.org/10.1111/mec.15633>
- Hellwig T., Flor A., Saranga Y., Coyne C., Main D., Sherman A., Ophir R., Abbo S. 2020. Environmental and genetic determinants of amphicarp in *Pisum fulvum*, a wild relative of domesticated pea. Plant Science 298:110566
- Lev G. Nemchinov, Samuel Grinstead, Brian M. Irish, Jonathan Shao. 2020. Identification and complete genome sequencing of alfalfa virus S diagnosed in alfalfa plants (*Medicago sativa* L.) from Washington State, USA. doi.org/10.1094/PDIS-06-20-1374-PDN
- Lin S, Medina CA, Boge B, Hu J, Fransén S, Norberg S, Yu L-X. 2020. Identification of genetic loci associated with forage quality in response to water deficit in autotetraploid alfalfa (*Medicago sativa* L.) BMC Plant Biol. 20: 303 <https://doi.org/10.1186/s12870-020-02520-2>
- Ma Y., A. Marzougui, C.J. Coyne, S. Sankaran, D. Main, L.D. Porter, D. Mugabe, J.A. Smitchger, C. Zhang, M.N. Amin, N. Rasheed, S. Ficklin and R.J. McGee. 2020. Dissecting the genetic architecture of Aphanomyces root rot resistance in lentil by QTL mapping and genome-wide association study. International Journal of Molecular Sciences. 21: 2129 <https://doi.org/10.3390/ijms21062129>

- Medina CA, Hawkins C, Liu X-P, Peel M, Yu L-X. 2020. Genomic-wide association and predication of traits related to salt tolerance in autotetraploid alfalfa (*Medicago sativa* L.). Int. J. Mol. Sci. 21(9):1-25, 3361; <https://doi.org/10.3390/ijms21093361>
- Wright D., S. Neupane, T. Heidecker, T. Haile, C.J. Coyne, R.J. McGee, S. Udupa, F. Henkrar, E. Barilli, D. Rubiales, T. Gioia, R. Mehra, A. Sarker, R. Dhakal, B. Anwar, D. Sarker, A. Vandenberg and K. E. Bett. 2020. Understanding photothermal interactions will help expand production range and increase genetic diversity of lentil (*Lens culinaris* Medik.) Plants, People, Planet DOI:10.1002/ppp3.10158
- Yu L-X, Zhang F., Medina CC., Lin S., Niu Y. Zhang T., Yang Q. Smith M., Hu J. 2020. Construction of high-density linkage maps and identifying candidate quantitative trait loci associated with verticillium wilt resistance in autotetraploid alfalfa (*Medicago sativa* L.). Plant Disease. 104:1429-1444. <https://doi.org/10.1094/PDIS-08-19-1718-RE>.

Abstracts/Conference Presentations (16)

- Bamsey L., Koh CS., Caron CT., Coyne CJ., Konkin DJ., Bett K. 2020. Long Read Assemblies Reveal the Complexity of *Lens* Genomes. International Plant and Animal Genome XXVIII, San Diego, CA
- Barbara Hellier. 2020. NPGS garlic collection. Culinary Breeding Network virtual sangra, Garlic Week - <https://www.culinarybreedingnetwork.com/sagre> (virtual).
- Brian Irish, Mike Cashman, Stephanie Greene, Leah Prescott, and Peggy Olwell. 2020. The National Plant Germplasm System and Seeds of Success programs: a successful, long-term collaboration. Colorado Plateau Native Plant Program, Vernal, UT.
- Brian M. Irish, Sara Shellenberger, Estela Cervantes, Lyndon D. Porter, and Deborah A. Samac. 2020. Assessing *Medicago* spp. genetic resources for disease reaction to *Phoma medicaginis*, causal agent of spring black stem and leaf spot of alfalfa. American Phytopathological Society (virtual).
- Brian Irish. 2020. Sinopsis del Sistema Nacional de Recursos Fitogeneticos del USDA. Agroecology Symposium hosted by the Universidad Agraria del Ecuador (virtual).
- Brian Irish. 2020. "NPGS BLM Seeds of Success Collection", Plant Germplasm Operating Committee, Curator Workshop (virtual).
- Brian Irish. 2020. "Pre-bred Disease Resistant Alfalfa Selections", Plant Germplasm Operating Committee, Curator Workshop (virtual).
- Coyne, Clarice. 2020. "New Pulse Genetic Resources" Pulse Crop Working Group Annual Meeting, Pullman, WA.
- Coyne, Clarice. 2020. "Artificial Intelligence and Plant Genetic Resources", Plant Germplasm Operating Committee, Curator Workshop (virtual).
- Coyne C.J., Ma Y., Zheng P., Main D., McGee R. 2020. Characterization of the USDA pea core plus collection for protein. CSSA-ASA-SSSA Annual Meeting (virtual).
- Lin S, Yu L-X, Norberg S. 2020. What potential is available for higher quality alfalfa. The Hay Expo, Kennewick, WA.
- Lin S, Medina CA, Norberg S, Combs D, Wang G, Shewmaker G, Fransen S, Llewellyn D, van Santen E, Yu L-X. 2020. Genome-wide association studies identifying multiple loci associated with alfalfa forage quality. Crop Science Society of America Annual Meeting.

CY 2020 Activity Report

- Medina AC, Lin S, Peel M, Liang M, Tang Z, Zhang Z, Ray I, Yu L-X. 2020. Genomic approaches for enhancing alfalfa resilience to abiotic stressors. Plant and Animal Genome XXVIII Conference.
- Medina CA, Samac DA and Yu L-X. 2020. Full-length transcriptome and regulation network in response to drought and salt stresses in alfalfa (*Medicago sativa* L.). Crop Science Society of America Annual Meeting.
- Peter Bretting, Brian Irish, and Christine Walters. 2020. The USDA ARS National Plant Germplasm System: Stewards of Our Agricultural Future. ARS Inform & Engage Agency webinar (virtual).
- Yu L-X, Medina CA. 2020. Genomics assessments of resistance to drought and high salinity in Autotetraploid Alfalfa (*Medicago sativa* L.) Plant and Animal Genome XXVIII Conference.

APPENDIX I – Multistate Review Committee (MRC) Recommendation.



**Western Association of
Agricultural Experiment Station Directors**

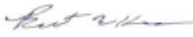
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<http://www.WAAESD.org>

April 13, 2021

TO: Scot Hulbert
Administrative Advisor
and
Ellen Yeates
Projector Editor

FROM: Bret W. Hess 
MRC Chair

RE: Proposal "W_TEMP_6: Maximizing Conservation and Utilization of Plant Genetic Resources and their Information"

The Western Region's Multistate Review Committee (MRC) met on March 25, 2021 to evaluate multistate research project proposals. The MRC considered a combination of peer reviews and evaluations by MRC members in their deliberations of project proposals. The proposal for W_TEMP_6: Maximizing Conservation and Utilization of Plant Genetic Resources and their Information received reviews by five peers and evaluations by two members of MRC.

Overall, MRC felt the proposed project is very valuable, with a long history of success. Collections have grown from 72,000 to 96,000 in the past 10 years. All five peer reviews were Excellent and primarily offered praise and discussed the importance of the project. The recommendation was to *Approve with minor revisions* for the following reasons:

- Research responsibilities of all participants are not clearly stated.
- The methods section is duplicated in the project proposal.

In addition to addressing MRC comments, please seriously consider comments of peer reviewers and MRC evaluators (available in NIMSS at: https://www.nimss.org/review/for_project/18811) when revising the project proposal.

A revised draft of the proposal must be submitted in NIMSS no later than May 21, 2021 to give MRC ample time to review the revised proposal and to allow ample time to draft another revision of the proposal if necessary. Additionally, please submit responses to review comments via the Technical Responses form that has been assigned to Ellen through NIMSS. Responses should indicate how the revised proposal has addressed recommendations of MRC, MRC evaluators, and peer reviewers.

Please do not hesitate to contact me if you have questions or need assistance.

APPENDIX II – WRPIS Staffing**Current Staffing (March 20, 2021)**

Position (Title)	Name	Federal/State	Position type
Pullman			
Research Leader/Station Coordinator	Vacant (2019)	Federal	PFT
Program Support Assistant	Carla Olson	Federal	PFT
IT Specialist	Vacant (CEC)	Federal	PFT
Biological Science Technician	Vacant (2019)	Federal	PFT
Seed Manager/Computer Specialist	Lisa Taylor	Federal	PFT
Seed germination Technician	Melissa Scholten	Federal	PFT
Plant Technician	David Van Klaveren	State	PFT
Plant Technician	Alec McCall	State	PFT
Farm Manager, Pullman	Saber Glass	State	PFT
Plant Technician	Julia Christian	State	PFT
Plant Technician	Deah McGaughey	State	PFT
Farm Manager, Central Ferry	Kurt Tetrick	Federal	PFT
Plant Technician (Farmer)	Jennifer Morris	Federal	TFT
Research Plant Pathologist	Abolished (2021)	Federal	PFT
Biological Science Technician	Shari Lupien	Federal	PFT
Agronomy and Safflower Curator	Vacant (2018)	Federal	PFT
Biological Science Technician	Bob Guenthner	Federal	PFT
Horticulturist	Michael Cashman	Federal	TFT
Cool Season Food Legumes Curator	Clarice Coyne	Federal	PFT
Biological Science Technician	Britton Bourland	Federal	PFT
Horticultural Crops Curator	Barbara Hellier	Federal	PFT
Biological Science Technician (Greenhouse maintenance)	Vacant (2021)	Federal	PFT
Biological Science Technician	Alex Cornwall	Federal	TFT
Biological Science Technician	Marie Pavelka	Federal	PFT
Phaseolus Bean Curator	Vacant (2019)	Federal	PFT
Biological Science Technician	Dawn Tachell	Federal	PFT
Prosser			
Temperate Forage Legumes Curator	Brian Irish	Federal	PFT
Biological Science Technician	Estela Cervantes	Federal	PFT

CY 2020 Activity Report

Plant Technician (Farmer)	Jesus Prieto	State	PFT
Alfalfa Genetics Research Geneticist	Long-Xi Yu	Federal	PFT
Biological Science Technician	Abolished (2021)	Federal	PFT
Biological Science Technician	Martha Rivera	Federal	PFT

APPENDIX II – Research, Service and Outreach Activities

- **January 10-14:** Clarice Coyne co-organized a workshop Genomics of Genebanks at the 2020 International Plant and Animal Genome Conference (PAG XXVIII), San Diego, CA.
- **January 17-18:** Brian Irish and Estela Cervantes participated in the Washington Hay Expo and conference in Kennewick, WA.
- **February 4 and 6:** Barbara Hellier, Dawn Tachell, and Lisa Taylor gave tours of PGITRU Seed Storage facility and greenhouse 109 to WSU Horticulture 202 lab classes.
- **February 5-August 25:** Clarice Coyne hosted visiting scholar, Saima Jameel, from the Nuclear Institute for Agriculture and Biology, Pakistan Atomic Energy Commission, Islamabad, Pakistan.
- **February 9-10:** Clarice Coyne hosted the Pulse Crop Working Group for a two-day workshop and stakeholders' reception.
- **February 10:** Barbara Hellier provided accessions information and historical documentation on *Phaseolus* accessions to a stakeholder.
- **February 13:** Clarice Coyne gave a tour of our Seed Facility and Pulse Crop seed working collection to the USA Dry Pea and Lentil Council and Northern Pulse Grower's Association Research Committee members.
- **February 21:** Brian Irish presented update to Unit during the annual Food, Fun and Fact Fest, Pullman, WA.
- **February 25-27:** Brian Irish and Elizabeth Martin presented research and participated at the 2020 Colorado Plateau Native Plant Program Annual meeting in Vernal, UT.
- **March 16:** Barbara Hellier attended, virtually, the Future of Lettuce Symposium.
- **March 17:** Barbara Hellier attended, virtually, the California Leafy Greens Annual Conference.
- **April 8:** Clarice Coyne attended the Annual Meeting of the P-POD project as scientific advisor (virtual).
- **April 21:** Clarice Coyne attended Research Leader Dr. Jinguo Hu's Retirement Celebration (virtual).
- **April 21:** Brian Irish planned, and hosted virtual Jinguo Hu retirement event.
- **June 3:** Barbara Hellier attended, virtually, the Temperate Forage CGC meeting and presented collection status updates on the forage legumes in her collections.
- **June 16:** Brian Irish, participated, presented on behalf of the Unit, and help facilitate the W6 RTAC Annual meeting.
- **June 16:** Brian Irish, along with Peter Bretting and Christina Walters, team presented an ARS-wide Inform and Engage webinar on the NPGS.
- **June 16:** Barbara Hellier attended, virtually, the W6 RTAC committee meeting.
- **June 18:** Barbara Hellier provided the *Beta* descriptor list and details on how they are taken to a stakeholder.
- **June 23:** Barbara Hellier attended, virtually, the NPGS PGOC meeting.
- **June 24-25:** Barbara Hellier attended, virtually, the NPGS curator workshop. On June 25 she presented on the new NPGS outreach video.
- **June 25:** Clarice Coyne gave a presentation at the PGOC Curator's Workshop (virtual).
- **July/August 2020:** Brian Irish remotely mentored BSA and 1890 Scholar James Pinkney. Scholar was supported by an ODEO Fellowship and involved experiences in managing genetic resources.

CY 2020 Activity Report

- **July 3:** Brian Irish, participated and presented to the Annual Metering of the Forage Legume Crop Germplasm Committee.
- **July 10:** Brian Irish participated in the Unit's annual Area Resources Management Plan meeting.
- **July 23-25:** Brian Irish helped host, participated, and presented in the virtual Plant Germplasm Operations Committee (PGOC) virtual meeting.
- **August 10:** Barbara Hellier attended, virtually, the Herbaceous Ornamental CGC meeting and presented a collection status update to the committee.
- **August 10-14:** Brian Irish participated and presented research as the Annual Meeting of the American Phytopathological Society virtual meeting.
- **August 21:** Barbara Hellier attended, virtually, the *Phaseolus* CGC meeting and presented a collection status update to the committee.
- **August 21:** Lyle Wallace gave a verbal report to the stakeholders of the *Phaseolus* Crop Germplasm Committee on the Crop Vulnerability Report and seed exploration for *Phaseolus polystachios*, virtually via Zoom.
- **August 24:** Barbara Hellier provided increase location information and passport data for *Phaseolus* accessions to a stakeholder.
- **September 14:** Barbara Hellier attended, virtually, the International Forage Conservation meeting.
- **September 25:** Barbara Hellier provided seed cleaning and storage information for *Artemisia tridentata* to a stakeholder.
- **October:** Brian Irish served on search/hiring committee for the USDA ARS Plant Introduction Research Unit, Ames, IA, Research Leader position (virtual).
- **October 1:** Brian Irish participated in the Plant Genetic Resources of Canada (PGRC) 50 Years Anniversary - Virtual Event.
- **October 1:** Clarice Coyne attended Plant Genetic Resources of Canada (PGRC) 50 Years Anniversary - Virtual Event.
- **October 21:** Brian Irish participated in a PGOC Subcommittee Review and PGOC bylaws Discussion (virtual).
- **November 8-11:** Clarice Coyne presented research posters "Characterization of the USDA Pea Core Plus Collection for Protein", "Genetic Dissection of Total Protein Concentration in Field Pea", Chaired Frank Meyer Medal presentation and participated in Editorial Board meeting at the CSSA-ASA-SSSA Annual Meeting (virtual).
- **December:** Brian Irish served on a search/hiring committee for the USDA ARS Subtropical Horticultural Research Station, Miami, FL, Ornamental Curator position (virtual)
- **December 2:** Barbara Hellier attended, virtually, the New Crops CGC meeting and presented a collection status report to the committee.
- **December 3:** Barbara Hellier participated in the Culinary Breeding Network, Garlic Week. She presented information about the NPGS garlic collection.