North Central Regional Plant Introduction Station

NCRPIS
AMES, IOWA

USDA/ARS
NC7 Annual Report
January 1- December 31, 2020

OILSEEDS Horticulture Maize Amaranth

Entomology Horticulture

Farm

Order Processing

Vegitables

Maize

Amaranth

USDA

Iowa State University
of Science and Technology

NCRPIS ANNUAL REPORT – 2020

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I. PROJECT TITLE:

NC7 "Plant Germplasm and Information Management and Utilization"

II. COOPERATING AGENCIES AND PRINCIPAL LEADERS (current):

A. Administrative Advisor

*J. Colletti, Interim Dean, Iowa State University, CALS

B. Regional Coordinator

*C. Gardner, USDA-ARS, Iowa

C. State Experiment Stations Representatives

Voting members:

1. Illinois	E. Sacks	7. Missouri	S. Flint-Garcia
2. Indiana	L. Hoagland	8. Nebraska	D. Santra
3. Iowa	T. Lübberstedt	9. N. Dakota	B. Johnson
4. Kansas	M. Stamm	10. Ohio	P. Jourdan
5. Michigan	A. Iezzoni	11. S. Dakota	M. Caffe-Treml
6. Minnesota	A. Lorenz	12. Wisconsin	W. Tracy

Non-voting participants:

13. California-Davis	R. Karban	30. Missouri	S. Flint-Garcia
14. Connecticut	M. Brand	31. Missouri	S. Jose
15. Delaware	R. Wisser	32. Nebraska	C. Urea
16. Hawaii	G. Presting	33. New Jersey	S. Handel
17. Illinois	J. Juvick	34. New York	J. Doyle
18. Illinois	G. Kling	35. New York	M. Gore
19. Illinois	S. Korban	36. New York	P. Griffiths
20. Illinois	D. Lee	37. New York	A. Hastings
21. Indiana	J. Janick	38. New York	M. Smith
22. Iowa	K. Lamkey	39. Oregon	A. Liston
23. Kansas	A. Fritz	40. South Dakota	L. Xu
24. Kansas	W. Schapaugh	41. Wisconsin	H. Kaeppler
25. Kansas	M. Jugulam	42. Wisconsin	S. Kaeppler
26. Kentucky	T. Phillips	43. Wisconsin	N. de Leon
27. Michigan	R. Grumet	44. Texas	D. Baltensperger
28. Michigan	J. Hancock	45. Texas	N. Subramanian
29. Mississippi	S. Popescu		

1. ARS National Program Staff, Plant Germplasm	*P. Bretting
2. ARS Plant Exchange Office	*G. Kinard
3. ARS Area Director, Midwest Area	*A. Pantoja
4. Cooperative State Research, Education and Extension Service	
5. National Center for Agric. Util. Research	*T. Isbell
6. National Institute of Food and Agriculture	*A. Stapleton
7. National Laboratory for Genetic Resources Preservation	*S. Greene

D. North Central Regional Plant Introduction Station, Ames, Iowa

See organizational chart, Figure 1 in the Appendix.

III. PROGRESS OF WORK AND PRINCIPAL ACCOMPLISHMENTS:

Personnel changes (June 2020 – May 2021):

Departures:

- Adam Spencer, USDA-ARS PFT Secretary Office Automation, September 2020
- Brady North, USDA-ARS Agri. Research Science Tech. (Maize Curation), August 2020
- Dr. Anna Testen, USDA-ARS Plant Pathologist, September 2020
- Dr. Candice Gardner, USDA-ARS Supervisory Plant Biologist, December 2020 (retired)
- Lucinda Clark, ISU Agri. Specialist II, January 2021 (retired)
- David Zimmerman, ISU Agri. Specialist II, May 2021

Promotions:

- Lisa Pfiffner, USDA-ARS Biol. Research Science Tech. (Entomology), (grade), September 2020
- Jeffrey, Schwartz, USDA-ARS Agri. Research Science Tech. (Oilseeds), (grade), August 2020

New Hires:

- Andrew Sherwood, USDA-ARS PFT Agri. Research Science Tech. (Horticulture), June 2020
- Dr. Colleen Warfield, USDA-ARS PFT Plant Pathologist, February 2021
- Samantha Armintrout, USDA-ARS Agri. Research Science Tech. (Maize Curation), May 2021
- Rita Mueggenberg, USDA-ARS PFT Secretary Office Automation, April, 2021
- Dr. Adam Vanous, USDA-ARS Term Support Scientist, GEM geneticist, March 2020

Transitions:

- Dr. David Peters, previously USDA-ARS GEM Project Coordinator at the PIRU accepts role of PIRU Research Leader, December 2020

Iowa State Position Reclassifications:

- Fred Engstrom, from Program Manager II to Assistant Director Research Administration
- Kathy Reitsma and Laura Marek, from Curator III to Research Scientist III
- David Brenner, from Curator II to Research Scientist III (also a promotion)
- Cole Hopkins, from Agricultural Specialist II to Agricultural Specialist I
- Samuel Flomo, from Agricultural Specialist I to Agricultural Assistant II

Vacant ISU Positions:

- ISU Agri. Specialist II (Maize Curation)
- ISU Agri. Specialist II (Vegetable Curation)

Appendix Figure 1 illustrates the organization of the NCRPIS staff and their roles.

Management of Federal and ISU Student Temporary Employees:
USDA-ARS resources were to provide for 19 student FTE (full-time equivalent) part-time temporary positions in FY 2020, primarily via the Research Support Agreement with Iowa State University. However, due to pandemic-associated restrictions, field operations were scaled back and only 21 student FTE were hired due to pandemic restrictions. The temporary positions support curatorial activities including regeneration, seed processing, viability testing, farm and facilities operations, IT support, and the GEM Project. Students were interviewed and selected by ISU Assistant Director of Research Administration Fred Engstrom. Marci Bushman, PIRU Program Support Assistant, managed the administrative aspects of all student hires, with support and guidance from Admin. Officer Candace Weuve and Program Support Assistant Orlando Guzman.

Budget:
We appreciate the support of the Agricultural Experiment Stations of the North Central Region, which have maintained their annual support and continued to provide $522,980 in Hatch funds. These funds support the salaries of our nine ISU staff members, their professional travel, and some expenses. In addition, Iowa State University's Agricultural Experiment Station provides support valued at over $400,000 annually that supports infrastructure, administration, and benefits for current NCRPIS-ISU staff members and retirees.

We are grateful that Hatch funding resources have been maintained. Their continued stability are critical to NCRPIS operations, now and in the future. Currently, about 97% of Hatch NC7 funds are devoted to the wages and salaries of the nine permanent ISU employees. In the near future we will be unable to provide incremental salary increases due to Hatch funding constraints. Future ISU wage increases without additional Hatch funding support will inevitably limit professional advancement, professional meeting travel, technical training, and temporary student hiring.

FY2020 USDA-ARS funding of the PI CRIS was essentially the same as final FY2014 funding (2.38M net to location), minus a one percent assessment for 'Big Data' and smaller assessments for Digitop and SAS licenses. The GEM CRIS received 0.23M additional funding to the level of $1.55M. Student hiring for summer 2020 was challenging. We attribute this to both the requirement for all agriculture students to complete internships, the growing disparity in what we can offer for wages versus other hiring opportunities, and pandemic constraints. ISU Assistant Director of Research Administration Fred Engstrom advertised positions more widely across ISU colleges and excellent students were employed from diverse academic backgrounds seeking a hands-on experience with plants. Their diversity of skills was put to good use.

Any reductions in funding will force reduction in student hiring, necessary for executing our genebank's mission. Like many other research units, our ability to cover all aspects of our mission is challenged. Our personnel strive to cover all functions and serve the collections entrusted to us and our stakeholders to the best of our ability. Given the high turnover since 2014, a great deal of time and attention has been paid to recruitment and hiring activities. A new position to replace the research leader who

retired in 2020 was recruited and filled by Dr. David Peters, formerly the GEM Project maize geneticist/coordinator.

Construction and Facilities:
Seed storage space is limiting and needs to be addressed within the next three to four years. The 2018 request to ARS leadership for support for a 2500 sq ft -20˚C cold storage building to support essentially doubling the longevity of viability of many of our taxa was added to the Agency Construction Plan, and funds provided in FY2020 were utilized for design. A contractor was hired to work with station staff on design and location considerations. Construction plans cannot progress without Congressional appropriation for the facilities. In general, space is extremely tight for all personnel and functions. Addition of this building will enable splitting the collection inventories appropriately between 4˚C and -20˚C, greatly extending longevity of viability.

The August 10, 2020 derecho caused significant damage to the roof of the 4C cold storage building, owned by ISU, and to cage frames and plantings. ISU supported replacement of the roof, which was original; their timely efforts to procure and contract the work are highly appreciated.

Greenhouse pest control continues to be augmented with biological controls such as green lacewings (*Chrysoperla rufilabris*), ladybugs (*Hippodamia convergens*), a whitefly parasite (*Encarsia formosa*), and rove beetles (Staphylinidae, *Dalotia*) to help control thrips and other insects.

Please see the Information Management section of this report for details on upgrades that continue to enhance the NCRPIS' information technology infrastructure, and the Farm Support Team section for updates on maintenance and equipment.

IV. PROGRESS IN GERMPLASM AND INFORMATION MANAGEMENT, RESEARCH, AND EDUCATION (D. PETERS and C. GARDNER):

(Part IV. summarizes the accomplishments and progress for calendar year 2020, presented in greater detail in the individual staff reports in the document.)

Technical Exchange:
An exchange relationship continues to expand between the NCRPIS maize genebank and the CIMMYT maize genebank in Mexico. In addition to regeneration of highland tropical maize at CIMMYT's Tolucca site, new curatorial and database personnel plan to spend time with Ames staff when travel is again possible, post-pandemic. Maize accession information resources and management tools are compared and augmented by both groups.

Acquisition and Documentation Highlights:
In 2020, collection development continued with the acquisition of 262 new accessions (Appendix Table 1). Details are provided in the individual curators' report sections. A historical perspective to provide comparison of acquisitions over the past nine years is provided below.

Year	# New Accessions
2020	262
2019	437
2018	293

Year	# New Accessions
2017	250
2016	786
2015	229

Year	# New Accessions
2014	766
2013	192
2012	470

The U.S. is now a partner to the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). Implementation by the NPGS is still under development as several Departments are involved. International collection continues to be challenging as countries adopt variations of the SMTA or other requirements that the NPGS cannot accept. Of ongoing concern is the successful entry of germplasm collected from international explorations into the U.S. It is critical that clean, pest- and pathogen-free seed be shipped or carried in by collectors; sufficient time needs to be devoted to collection sample preparation and sufficient care post-collection. Excellent quantities of seed provided by collectors of many new accessions have made a significant proportion available and distributable immediately.

Original seed samples continue to be scanned in order to provide useful visual references for comparison of regeneration lots with original samples.

Regeneration and Maintenance Highlights:
Regeneration was attempted for 1,514 accessions. Of these, 915 were harvested (Appendix Table 2); efforts are described in the curators' report sections. Contrasts with previous regeneration attempts are provided in the table below. Differences may reflect challenges due to pandemic hiring constraints as well as damage from the derecho. Overall collection availability is 79%, an increase of 2% over 2018, despite 8% growth in collection size since 2006. Part of the increased availability has been an increased focus on inactivating accessions which were received with low viability and could not be maintained, and resolution of duplication.

Year	# Accessions Regenerated
2020	915
2019	1,562
2018	1,245

Year	# Accessions Regenerated
2017	1,601
2016	1,033
2015	1,627

Year	# Accessions Regenerated
2014	1,230
2013	1,148
2012	759

Continued positive results from use of a contracted tropical maize winter nursery planted in fall 2020 near Puerto Vallarta, Mexico encourage us to continue to invest in these efforts to increase maize germplasm availability. Two tropical maize ex-PVP inbred lines from Korea were grown under quarantine permit in a winter greenhouse on the Iowa State University campus. Plant growth results were disappointing, likely due to a combination of light and temperature resources.

Assistance in regeneration was provided by USDA-ARS staff of Parlier, CA for increase of wild *Helianthus* taxa. *Daucus* regeneration efforts were supported by seed increases from Seminis Vegetable Seeds (L. Maupin) and from Bejo Seeds (R. Maxwell). USDA-ARS in Salinas, California (B. Mou) supported seed increase of domesticated spinach, and USDA-ARS in St. Croix supported increase of 21 tropical maize inbred lines and populations.

USDA-ARS staff of Mayaguez, PR (R. Goenaga) and the St. Croix quarantine nursery staff supported regeneration of tropical maize accessions. Raleigh ARS GEM Project Coordinator Matt Krakowsky provided increases of GEM lines and the Ames GEM team regenerated and provided GEM lines. CIMMYT, the International Center for Maize and Wheat Improvement, regenerated highland maize, which has very specific growing requirements, at their Tolucca site.

Spinach regenerations continue to be supported by cooperative efforts between the USDA-ARS and Sakata Seed America, Inc. in Salinas, CA.

Accessions backed up at the National Laboratory for Genetic Resource Preservation (NLGRP) in Ft. Collins in 2020 numbered 1,454, with an overall collection backup average of 79%. There is wide variation for percent backup across the various crop collections, from 10% (teosinte, a maize ancestor) to 100% for flax (Appendix Table 2). Variation may be due to lack of appropriate environmental conditions to support the growth and reproductive requirements for some taxa, lack of methods to induce and synchronize flowering for some, and/or insufficient representation of male/female individuals, among other factors. Seed of 2,008 accessions was prepared and shipped to Ft. Collins for inclusion in the NPGS deposit to the Svalbard Global Seed Vault.

Year	# Accessions Backed Up
2020	1,454
2019	623
2018	795

Year	# Accessions Backed Up
2017	595
2016	428
2015	431

Year	# Accessions Backed Up
2014	1,231
2013	781
2012	799

Distributions:
Approximately 55% of the 2020 germplasm distributions were to international and 45% to domestic requestors. This proportion is unusual compared to an average historical balance of 33% international and 67% domestic distribution. Distributions continued to reflect high demand in 2020 (Appendix Table 3). The 2018-2020 timeframe reflects 25-50% higher distributions than the previous three years.

Year	# Items	# Unique Accessions	# Orders	# Requestors
2020	46,627	21,089	1,153	836
2019	54,232	22,271	1,296	902
2018	61,124	23,229	1,414	1,000
2017	55,474	22,801	1,410	1,019
2016	39,520	18,093	1,254	963
2015	34,188	14,279	1,186	945
2014	41,655	17,558	1,285	993
2013	40,409	17,788	1,523	1,204
2012	45,115	18,811	1,632	1,344
2011	38,402	18,634	1,501	1,180
2010	26,651	13,226	1,183	820

Non-research requests (home gardeners) continue to heavily target vegetable and ornamental germplasm, more than one-half of all orders to NC7 are cancelled non-

research requests; other NPGS sites are also heavily targeted. Home gardeners are redirected to other sources of commercially available materials. Although our resources cannot support maintaining and distributing the collections to home gardeners, we inform these requestors about plant genetic resource conservation and encourage interested individuals to save seeds, conserve them, and share germplasm and associated information. The proliferation of websites instructing non-research requestors how to deceive curators at various germplasm sites in order to get free germplasm continues to be problematic. The careful efforts that go into each and every increase, characterization, imaging, processing, storage, viability testing, and distribution surely make these seeds among the most expensive to provide. GRIN-Global's user friendly order module also helps individuals to select more diverse germplasm from a number of NPGS sites at once. Software tools are being developed by the DBMU (Database Management Unit, Beltsville) that will enable rapid classification of NRR (non-research requestor) orders and reduce personnel processing time.

The relative numbers of distributions generally correlate well with the proportional makeup of the collections and vary from year to year, although demand for maize is usually greater than for other crops, but in the pandemic year oilseeds increased and maize decreased.

Curator	Collection Size 2020	% of Total Collections	% of 2020 Distributions	% of 2019 Distributions	% of 2014 Distributions
Brenner	9,517	17	16	21	14
Carstens†	3,926	7	1	1	<1
Marek	12,872	23	29	32	16
Millard/ Bernau†	19,966	38	31	32	35
Reitsma	7,950	15	23	14	28
Totals	**54,231**	**100**	**100**	**100**	**100**

†Barney collections assumed by Carstens in late 2015; Bernau became our 2nd maize curator in 2019.

Research demand for our plant genetic resource collections continues to be very high; requests for diversity and relationship analyses, disease and pest resistance, biofuel, and health and nutrition contribute to these increases, as well as for basic research applications such as photoperiod response, and an array of performance traits. There was unusually high demand in 2017-2019 for almost all major crop species. Germplasm requests continue to be driven by publication of information from genomic (genotyping by sequencing) and phenotypic analyses projects, some or the studies are supported with SCRI, AFRI, or NSF funding.

Evaluation and Characterization:
With the enhancements made to the 'Attachment Wizard' that work in conjunction with GRIN-Global, image organizing, and loading has rapidly progressed. A large volume of accession-associated images and other types of documents are being attached to accessions, orders, and inventories. In 2020, personnel resources limited image loading capacity with only 2,844 images loaded (compared to more than 5,200 images in 2019). Loading of observation data substantially increased, with 41,328 observations associated with 7,379 accessions (compared to more than 26,500 trait observations loaded/associated with 2,764 accessions in 2019). For the NC7

collections, 42,492 accessions have one or more trait observation data points available via the GRIN-Global database, (https://www.ars.grin.gov/npgs/) and more than 17,800 have at least one associated image.

In 2020, more than 7,000 accessions were monitored for germination, seed increase, observation, evaluation and characterization for a wide array of descriptor information (Appendix Tables 2, 4). Other uses include pathogen testing to meet international distribution requirements and back up and herbarium preparation.

Information technology and telecommunications:
The NCRPIS staff continues to provide expertise and leadership for the development of GRIN-Global (GG), the successor to the GRIN system, implemented in 2015. This has been the sole primary focus of NCRPIS developer Pete Cyr since 2008, and a major focus of two other NCRPIS staff members, Mark Millard (system analyst) and Lisa Burke (Advisory Committee Chair, beta testing, training) with substantial time invested by additional personnel. The Database Management Unit (DBMU) in Beltsville, MD is responsible for hosting and maintaining the database and the system, developing the public interface, GRIN Taxonomy, changes to the system's Middle (business) Tier and administration. Periodic video training conferences continue to be offered by DBMU personnel (contract documentation specialist Marty Reisinger) for NPGS site personnel training, as for the past five years, and other training as requested.

Software development efforts continue to center on the development and deployment of user tools that improve curatorial workflows, user experience, applications for data capture and transfer, enabling increased availability of accession-associated information to the public. These efforts are facilitated by contributions from germplasm stakeholders in the U.S. and abroad, as we seek examples of use cases and desired features and functionalities of the new system. A formal process is used to submit and address enhancement requests, prioritize development, assign work to developers, and to securely share new software applications between GG adopters to extend the system's functions and features.

Currently 29 national or international genebanks have implemented the GRIN-Global system for genebank use, and many of these have live public interfaces. Another 16 genebanks are in the process of evaluating and/or implementing the system, truly evidence of global adoption of this valuable resource.

For almost five years, the NPGS has utilized a GRIN-Global Advisory Committee (AdCom) as a forum for genebank personnel and developers to identify development needs, prioritize them, test, and approve software for release. The AdCom is chaired by NCRPIS staff member Lisa Burke and has been highly productive. An international AdCom was formulated with participation by key personnel from the Crop Trust, the US NPGS, CIMMYT, and CIP, and confers monthly. A process was developed for international development products to be checked into branches of the Git vault (maintained by the Trust at CIMMYT) and then vetted.

One focus of our current ARS Program cycle is to develop inter-operability between GG and other key information providers' portals, examples including MaizeGDB,

Gramene, LIS (Legume Information System), or GOBii. Pete Cyr developed and implemented the BrAPI specification using a RESTFUL webservice interface and integrated it with the GRIN-Global middle tier. It is being tested by genomic database personnel on a test server residing in Ames.

Please see the IT section for technical details of NCRPIS support activities and GRIN-Global development progress

Germplasm's Viability and Health:
In 2020, about 10% of the collection was tested for periodic viability maintenance (5,308 accessions). An additional 4% of the collection (2,300 accessions) was tested to satisfy other requirements (see section F, Germination). Documentation of collection quality necessitated the increase of resources devoted to this effort. A concerted effort is being made to assure all seed lots 10 years or older have current germination information. Our storage conditions (4 C, 25-35% relative humidity) are very good, and the efforts devoted to seed cleaning ensure storage of very clean seed lots, important to longevity of viability. Construction of a -18C cold storage building would provide for much longer period of viability for many of our taxa. This would bring significant cost savings over the long term, as most of the collection's seeds lose viability long before inventory supply is depleted. Less frequent regeneration need would enable more rapid progress in making the collection fully available.

ARS Pathologist Dr. Anna Testen has provided each curatorial team with guides and protocols for improved field and greenhouse practices to support healthy plant and propagule production. Collaborations continue for development of methods to eliminate the bacterial fruit blotch pathogen, *Acidovorax avenae*, from *Cucumis melo* seed.

Field inspections were made for all crops. All cucurbit seedlings were screened routinely for presence of Squash Mosaic Virus via ELISA; Outcomes are detailed in the pathology section of this report.

We continue to test for adventitious presence (AP) of genetically engineered organisms (GEO) in maize germplasm accessions new to the NCRPIS and sampled newly produced seedlots, using a commercial laboratory vendor.

Insect management:
The Entomology staff provided six insect pollinator species to control pollinate 989 accessions. Honeybees continue to be the primary pollinator used in the NCRPIS regeneration program, followed by the Alfalfa Leafcutter Bee (ALC).

Detailed, interesting observations and interpretative information regarding their field pollinator research activities can be found in their extensive section of the annual report for information on their continuing efforts to enhance the pollination program's effectiveness and efficiency. Substantial reporting is devoted to this team's activities because of the uniqueness of this project, limited sources of such information, and relevance to the broader germplasm conservation world. Feedback and suggestions on experimental approaches are welcomed.

Effectiveness of insect pollinators on cross-fertilization of caged plantings, and preservation of the genetic profile of the accessions is considered during regeneration.

Enhancement:
The Germplasm Enhancement of Maize Project (GEM) works with 68 active public and private collaborators to adapt exotic maize germplasm to broaden the genetic diversity of temperate U.S. maize production and provide unique, key priority traits. Research and breeding are designed to improve exotic germplasm introgression methods, to provide unique sources of allelic diversity, and to identify traits and genes to support improvement of agronomic productivity, disease resistance, insect resistance, and value-added grain characteristics of importance to human health and nutrition. International collaborators are screening GEM germplasm for late wilt, tar spot, maize rough dwarf virus, corn stunt, and others.

The Ames and Raleigh, NC GEM Projects and public collaborators have released 332 lines from 2001-2020 representing more than 60 maize races. An important goal is development of a set of inbred lines representative of the diversity inherent to all of the races of maize. In addition to traditional introgression methods, the project has released 204 doubled-haploid (DH) maize lines in partnership with the ISU Doubled Haploid Facility. The next set of DH lines from the allelic diversity project will be released in Fall 2021. These lines have one-quarter exotic, three-quarters temperate background. In 2017 and 2018, the GEM Technical Steering Group's private sector members tested 47 GEM lines from the Ames and Raleigh, NC programs internally on their own proprietary testers. These data enabled calculation of the first general and specific combining ability estimates for GEM germplasm on company tester lines, important for breeders and researchers to gain insights into effective use of these genetic technologies. A second, similar trial is being conducted using 30 lines released by the projects since 2016, again by the private sector collaborators.

Photoperiod sensitive tropical maize often does not flower until September in Ames. GEM and maize curatorial teams have continued to collaboratively develop an effective method for photoperiod control in the field. The sunflower project has also used photoperiod control effectively to induce flowering in certain wild sunflower accessions. Photoperiod-control environment capacity on the order of one to three acres would be very useful in maintaining and providing unique genetic resources.

GEM field days are held every September and are well attended by scientists, breeders, and graduate students. The field days offer a unique opportunity for more molecular-focused researchers to understand the diversity of the materials available for research, and the activities that support germplasm development.

Outreach and Scholarship:
Normally our staff hosts more than 400 visitors per year and participates in a wide range of outreach activities involving students from grade K to postgraduate level and outreach events to civic and other organizations about germplasm conservation and management, and the work done at the NCRPIS. These events simply were not possible during the 2020 pandemic year. Scientific and technical staff members continue to publish scholarly journal articles, make presentations at scientific meetings, and supervise graduate research programs.

Current and future foci:
Processes involved in regeneration, characterization, and making viable germplasm available are labor intensive. Resources do not allow maintenance and regeneration efforts (including viability testing) to keep pace with demand. We continue to try to improve conservation methods to better use the resources available to us, and to develop labor and resource saving technologies. ARS leadership approved design of a -18˚C cold storage building in FY2020 order to extend longevity of seed viability, and we hope to receive resources for construction in FY2021. We continue to evaluate activities that can be reasonably reduced without sacrificing collection health and quality, and to improve efficiency.

Continued emphasis will be placed on communicating with research stakeholders to address development of comprehensive, genetically diverse collections to meet research and development needs. More emphasis has been requested for advanced breeding materials, doubled haploid germplasm, mapping populations, single mother trees, and ephemeral genetic resources derived from NSF, AFRI, or SCRI-funded research.

Climate change is forcing researchers to renew efforts to identify superior forage cultivars as well, and interest has increased in collections of suitable species. A 'gap analysis' process is utilized to examine distribution of crops and their wild relatives; information sources include herbarium records, floras of various countries and ecoregions, predictive analyses based on GIS layers and habitat information, and scholarly publications that cite plant sources, traits, and performance attributes. Wise selection of targets is important to managing collection growth and effective use of resources. The horticulturists' report details how collection priorities have been determined, and how gap analyses affect these priorities.

Better characterization information is essential to enable well-targeted use of the collections, especially given the increasing constraints of limited research and conservation resources. Availability of PGR significantly impacts research applications, including taxonomy.

Implementation of new optical and spectroscopic-based technologies are in process and we hope they will enable us to better understand seed properties and improve the quality of our seed inventories.

Software development efforts will continue to center on the development and deployment of GRIN-Global resources, and on information management tools that can facilitate information transfer from various providers and integrate the information in useful ways for researchers. These efforts are facilitated by contributions from germplasm stakeholders in the U.S. and abroad, as we seek examples of use cases and desired features and functionalities. A formal process is used to submit and address enhancement requests, prioritize development, assign work to developers, and to securely share new software applications between GG adopters to extend the system's functions and features.

V. IMPACTS OF GERMPLASM USE BY NORTH CENTRAL REGIONAL RESEARCHERS:

Impacts of germplasm use by the researchers at the NCR institutions:
A detailed list of examples of germplasm use in research being conducted at NCR institutions was not requested of the RTAC members this year. NC7 Region researchers typically account for nearly half of domestic plant germplasm distributions from the NCRPIS. Requests for germplasm continue to increase for research as well as non-research use. Requests become increasingly better targeted as the quantity and quality of information associated with the collection improves, thus sharing of findings resulting from use of NPGS germplasm, linked with the germplasm's identity and source, is critically important.

The linkage of the GEM Project, the maize curation project, and public and private collaborators throughout the U.S. facilitates the use of exotic maize germplasm by public and private sector maize researchers. This unique partnership offers great potential for diversifying the genetic base of U.S. maize production, the mission of the GEM Project.

Linkages among project participants and with other projects/agencies and contributions of the Regional Technical Advisory Committee:
Linkages are driven primarily by common research interests and objectives and by the heritage of the germplasm material utilized for research and education. All states utilize germplasm provided by the NCRPIS and many of the other 19 NPGS sites; the states have a complex array of collaborative research efforts between their institutions, and with the plant genetic resource curators at the NPGS sites.
The Regional Technical Advisory Committee (RTAC) has provided valuable direction in the following areas:

- Requesting and suggesting organizational structure of information needed to determine project impact and provide accountability. This includes advice on useful formats for analyzing and evaluating the nature of distributions, whom they benefit, and how benefits are realized, which are essential for determining the impact and value of the project.
- Identifying needed improvements to the public GRIN interface.
- Providing input from their respective AES Directors to curators, genebank and other administrators.
- Providing guidance to increase the NCRPIS program's relevance to NCR stakeholders.
- Providing technical expertise, particularly in the areas of diversity assessment and taxonomy.
- Providing added breadth in understanding issues at genebanks beyond the NCRPIS.
- Understanding the challenges faced by public researchers partnering with other public institutions' researchers, both governmental and non-governmental. This has provided useful insights for ARS and NCR administrators to guide programmatic decision-making, as well as operational guidance; this function is key because of its direct impact on the public interest as well as the specific research interests of more directly involved stakeholders.

The technical committee gatherings provide an opportunity for the AES Directors' representatives to learn about and understand strategic issues which impact how their institutions operate and how they can cooperate more effectively to address their mission in today's environment, and then provide this information to their Directors. Among the benefits for the representatives are the opportunity for exposure to research in areas outside their own area of expertise, leading to greater understanding and insights, and the opportunity for service to their institutions, to the NPGS, and to germplasm security.

The 2020 NC7 RTAC meeting was hosted by the University of Minnesota and NC7 RTAC member Aaron Lorenz. Minutes of this meeting can be found on the NIMSS website.

Some of the NC7 RTAC's specific suggestions and contributions include the following: (from the meeting minutes):

- Concurrence of the review and approval of the 2019/2020 NC7 Hatch Project budget by the NCR AES Directors.
- The committee recognize and thank Host Professor Lorenz, Academic Advisor Joe Colletti of ISU, and colleagues who contributed.
- Discussion of the need to train the future plant genetic resources workforce, as 1/3-1/2 of curatorial personnel are retirement eligible. A Higher Education Challenge Grant was awarded to Dr. Pat Byrne, Colorado State University, to provide resources to support development of academic and practical training resources.
- RTAC members expressed concern and encouraged NC7 curators to pursue genomic characterization of all collections and to make this information accessible.
- RTAC members encourage development of a web vehicle to automatically request information on findings/data resulting from use of plant genetic resources and facilitate inclusion of such information in the public GG system, thus extending the utility of these resources for further research.
- Summaries of research projects using plant genetic resources by the NC7 RTAC members at their institutions.

VI. SUPPORT TEAM REPORTS:

A. <u>Farm (F. Engstrom, B. Buzzell, C. Hopkins)</u>

We supervised and coordinated daily operations at the NCRPIS farm, including management of all facilities, fields, and greenhouse space. We conducted all pesticide applications in the field and campus greenhouses. We responded to maintenance requests from staff members at the farm and the campus location. We selected, coordinated, and scheduled the student labor force. We coordinated and completed facility construction and upgrades along with safety inspections. The COVID-19 pandemic significantly changed our operation. The challenges forced us to find alternatives to the traditional methods we have been accustomed in our operation. Increasing social distancing mandates fewer people in a given area while our needs are labor heavy.

Recent changes in field operations have allowed lower staffing levels for spring field preparations. In the past, all cage frames were removed from the field at the end of the season to allow fall tillage and crop rotation with a row crop. We have created "permanent" fields where the cage frames remain year-round decreasing the labor needed to remove, and then grid, measure, and reinstall the cages annually. This process also allows us to have turf in the alley ways which then allows access to the fields regardless of precipitation events. New equipment that fits physically in the cage is a key factor allowing this development. The key factors in choosing this operation was due to perceived soil compaction affecting accession growth and health due to equipment traffic patterns, erosion of exposed soil between cages for weed management, and access to cages after a rain event. One benefit that has been realized this year was the decreased labor effort which has been instrumental in a year of COVID-19.

Labor:
During 2020, 32 applications for hourly employment were received and reviewed. There were approximately 20 interviews, resulting in 12 new and 18 returning hourly employees hired. Currently there are 11.5 (FTE) Biological Science Aides working at the NCRPIS.

NCRPIS Farm Crew Personnel:
- Fred Engstrom, (Assistant Director of Research Administration) Joined the staff July 1, 2016.
- Brian Buzzell (ISU Farm Equipment Mechanic) joined the staff in May 2002.
- Cole Hopkins (ISU Agricultural Specialist I) joined the staff in September 2016, and assists the vegetable project half-time, and facility operations half-time.

Maintenance projects:
During the past year the farm staff initiated and completed the following projects which enhanced the efficiency and safety of the station operations.

1. Coordinated conducting soil compaction samples with the Oilseeds Technician across the station's fields. This will be used to help identify cultural practices that impact plant health.
2. Installed twelve hand sanitizing stations across the facility due to COVID-19.
3. Replaced exterior building security lights with LED units.
4. Arranged for repair of compressors, HVAC equipment in multiple areas.
5. Replaced various light fixtures with energy efficient LED lights in offices and other work areas as needed.
6. Continue to install additional Monnit temperature and humidity sensors in facilities to track trends and alert us to abnormal conditions.
7. Temporarily repaired and then coordinated repair of damaged buildings from the August Derecho event. Seed storage roof was severely damaged, the west machine shed door had to be replaced and a roof panel from greenhouse three were the most affected structures.

Purchasing:
Fred Engstrom coordinated purchasing for the NCRPIS farm: this task included gathering and summarizing requests, writing specifications, and obtaining supplies for the farm.

Equipment Purchased:
1. A six-foot-wide soil spader was purchased and utilized starting the fall of 2020 allowing the removal of compaction zones in the footprint of the cages.
2. An additional zero turn mower was purchased to assist in the maintenance of the station.
3. Two additional gators were acquired to assist with crew transportation and the requirement for social distancing.
4. The GEM Project purchased a seed processing line system and incorporated seed treatment and barcoding, creating a "one pass" handling system for maize topcross seed shelling, cleaning, treating, and packaging.
5. The GEM Project contracted for a thorough updating of the 20-year-old New Holland plot combine and for updating of the planter units to correct plant depth and consistency issues. This planter is used by both maize curation and GEM Projects.
6. Two DuBois seed counters and a DuBois small volume seed treater were purchased. Both utilize barcode technology to confirm seed source identity and control seed treatment volume.

Tours:
During 2020 there were fewer than 70 visitors due to COVID-19 restrictions.

Staff Training:
We conducted Tractor and Utility Vehicle Safety, Hazzard Communication, and Worker Protection Standard training sessions for the new staff and student employees as well as annual updates for existing staff.

B. Information Technology and Telecommunications (P. Cyr, J. Perrett)

Jesse Perrett served as the first line of support for NCRPIS during 2020. Jesse is supervised by Pete Cyr who is dedicated to the GRIN-Global project. Jesse supervised Kurt Kabriel, ORISE intern in assisting with IT/IM related tasks from January through May. The following list outlines the progress made by the IT team during 2020 at NCRPIS.

Equipment:
As of December 2020, the NCRPIS had 50 desktop and 40 laptop/tablet workstations installed for use by permanent staff members and part-time temporary student help. All station computers are equipped with solid state drives, have at least eight gigabytes of memory, and quad core processors. The centralized functions required by the station were supported by 11 physical servers and around 20 active virtual servers including those used for file storage, intranet, backups, and access security systems and monitoring.

A firewall was maintained order to provide enhanced security as well as increased network performance in line with the 10-gigabit server network infrastructure. Each server rack is protected by a battery backup. In addition, a station generator system will provide power in the event of power grid failures. The generators in conjunction with the individual rack mounted battery backups should limit the possibility of power failure-related server issues.

The station continues to implement virtual servers wherever possible to better utilize existing server capabilities and improve efficiency. Virtual server hosts use solid state drive tiered storage systems utilizing the technology built into Microsoft Windows Server 2019 to enhance storage performance of existing servers at minimal cost.

Deployed 20 laptop and desktop computers with all required equipment to set up users for teleworking during the Covid-19 pandemic. Ensured all users had remote access to needed files, email systems, and networking capabilities for remote work.

Decommissioned/uninstalled BigFix and deployed new Tanium clients on all computers for department management of updates and patches.

Configured a new dock and computer on the SRES corn planter and configured it to work with the existing tractor, GPS, and planter. Also ordered and configured new docks and a rugged tablet computer to be used for both the combine and planter. The new computer was configured properly to control the combine measurement equipment.

Replaced microscope cameras and the computer in the Germination lab. The new cameras allow for much higher resolution imagery as well as real time monitoring.

Worked with Qualysense to troubleshoot and deploy a new algorithm for sorting Haploid corn on the Q-Sorter. Discovered problems with belt speed and suction related to algorithm problems and was able to work with Qualysense to get a new version of the software that would allow the manipulation of the belt speed and seed size which improved the efficiency of the sorting operation greatly. Also helped Qualysense to deploy software updates to the local hardware.

Implemented new Microsoft Office Mobile on all station employee cell phones. New system required a complete wipe and reconfigure of all government cell phones and the implementation of all new systems on the phone to allow utilization of Lincpass credentials on the phones for email configuration purposes.

The station continues to utilize the Monnit wireless environmental monitoring system with over 90 sensors around the station. This allows for real time monitoring of temperature and humidity for plant material and valuable equipment throughout the station.

Responded to numerous Client Experience Center (CEC) data calls for converting IT systems to a new centrally managed CEC implementation.

Ensured all computers were compliant with department installations of Tanium for patch and software deployment and update monitoring as well as reporting to ARS IT specialists.

Updated GRIN-Global label programs with enhancements and fixes as needed. Worked with germplasm management staff to configure label printing for simplicity and functionality.

Multiple SharePoint lists are used at the station for tracking purchasing requests, maintenance requests, farm spray records, and other issues. The lists allow multiple users to add and monitor requests for new supplies and requests simultaneously.

Security system cameras are installed around the station to monitor property entrances and outside activities. Two security cameras needed replaced this year.

Staff printed over 6000 field-ready wooden stakes. Issues with print quality and print consistency were resolved to ensure minimal misprints.

Software:
All workstations at NCRPIS use Windows 10. Microsoft Office 2013, Microsoft Office 365, Adobe Acrobat Professional DC, Adobe Creative Suite, Pulse Secure, ActivClient, Java, Tanium, and the GRIN-Global Curator Tool were installed on systems as necessary. Laptops and tablets were encrypted by bit-locker.

PDQ Inventory and PDQ Deploy were also used for deployment and monitoring of non-Windows software packages such as the GRIN Global curator tool.

Documentation:
Updated station information system security documentation and disaster recovery plans. The new documentation includes information necessary to repair or re-configure station IT systems in the event of a natural disaster or equipment failure.

Weather station history data was provided via SharePoint to allow users to download current and past weather data including calculated GDU and CHU (heat unit) data. The station uses a SharePoint Server 2016 Intranet site for advanced document management and retention. Umbraco website management tool was used to configure the NCRPIS public webpage on USDA's website and for posting IT support videos and training documents, and information about farm operation, safety, and health to the NCRPIS intranet website (internal use).

Plans for 2021:
- Continue to update documentation for IT systems and services.
- Perform information systems disaster recovery trials with non-IT Specialists assistance.
- Replace user desktop systems with laptops and extended warranties and docks to prepare for the Client Experience Center (CEC) implementation.
- Continue to replace NCRPIS workstations on an as needed basis (targeting a 3-5 year lifespan for daily use workstations).

GRIN-Global:
GRIN-Global is the product of a partnership between the USDA-ARS NPGS, the Global Crop Diversity Trust and Bioversity International to develop a new genebank information management system that it can be deployed on any size computer with a minimum amount of effort and cost. The GRIN-Global system is currently implemented by 29 international genebanks and is being evaluated for adoption by additional 16 other genebank entities. GRIN-Global is designed to support an unlimited number of languages (seven languages are currently installed) and has the capacity to store the genebank data in one of the four relational database engines (SQL Server, Oracle, MySQL, or PostgreSQL). The complete GRIN-Global system can be installed on a stand-alone desktop computer or in a network server/client configuration.

The USDA-ARS GRIN-Global development team is located primarily in Ames, Iowa (PIRU) and in Beltsville, Maryland (DBMU, or Database Management Unit). Pete Cyr is responsible for the Curator Tool, Search Tool and development of associated wizards and forms. Curator Tool 1.21.4.16 is in beta now and will soon be released for production use at NPGS and international genebanks. In FY2020 Mr. Cyr developed 8 new versions of the Curator Tool Software Suite for testing and distribution. The 8 upgrades include 47 enhancements and 14 bug fixes in various components like the Order Wizard, Cooperator Wizard, Viability Wizard, Curator Tool and the Search Tool. In addition to the Curator Tool development work, Mr. Cyr has recently developed and implemented the BrAPI specification and integrated it with the GRIN-Global middle tier software. A test/pilot GRIN-Global server hosted at a NCRPIS server in Ames is being used by developers at MaizeGDB, SoyBase, PeanutBase, and Legume Information System to test the new capabilities of this BrAPI enhancement to the server-side middle tier. With the BrAPI specification enabled in the GRIN-Global server system it will now be easier for other model organism databases, genebank systems, and various germplasm related public websites to interoperate with GRIN-Global system data. Mark Millard serves as the business analyst, and Lisa Burke serves as chair of the GRIN-Global Advisory committee.

DBMU personnel at the NGRL in Beltsville are responsible for the administration of the GRIN-Global database, the Middle Tier and security features, and the public website (PW), https://npgsweb.ars-grin.gov/gringlobal/search.aspx? PW 2.0 is currently under development. The NGRL botanist responsible for GRIN taxonomy works closely with DBMU developers.

Plans for 2021:
- Enhance the BrAPI implementation currently being tested to include native GRIN-Global security so that the BrAPI interface can be used for inserting and updating data in the GRIN-Global database using mobile applications in the field.
- Enhance the Attachment Wizard to support all attachment tables in the GRIN-Global database.
- Enhance Curator Tool to support SQL Server Reports in addition to Crystal Reports.
- Enhance the Curator Tool to leverage modern connectivity technology (like gRPC) to replace the legacy SOAP XML communication technology currently being used.

- Enhance the Curator Tool installation process to minimize the need for administrator permissions steps required to make the Curator Tool work with recent Microsoft security changes.
- Enhance the Curator Tool to present a user-friendly interface for managing dataview tabs, Crystal Reports, and Wizards gracefully.

C. Information Management-Germplasm Collections (S. Estrada)

Acquisition:
The North Central Regional Plant Introduction Station (NCRPIS) acquired 262 new accessions in 2020. Of these new accessions, 46 were received from within the National Plant Germplasm System (NPGS) through exploration and transfer 46 were received from the NLGRP, and 46 accessions from the GEM project. Details of specific acquisitions are found in the curators' sections of this report.

As new accessions are recorded in the Germplasm Resources Information Network (GRIN-Global) database, we include as much passport information as possible. Typical passport information would include a source history, cooperator records, collection-site descriptions and geographic coordinates for wild collections, pedigree, secondary identifiers, IPR considerations, and any additional pertinent information provided by the donor. An excel workbook streamlines the assembly of passport data and aids in loading the data to the GRIN-Global database.

Maintenance:
Curatorial assistance was provided by processing requests for taxonomic re-identifications and nominations of accessions to the inactive file. In total, 60 accessions received taxonomic re-identifications and 68 accessions were inactivated. 19 accessions were inactivated due to failure to germinate or were never received, and 48 accessions were inactivated due to duplication.

Additionally, 388 accessions were assigned PI numbers, 376 of which were *Zea mays* accessions from various collections including but not limited to: CIMMYT890 (210 accessions), Goodman-Buckler lines, CI accessions, and GEM lines. Crops curated by David Brenner were assigned 12 PI numbers to 8 umbels and 4 spinach accessions.

The NCRPIS continues to work on a project to digitize all paper documentation related to accession provenance, management, and performance. In total, 9,023 documents were uploaded to the GRIN database. This included 167 new Passport documents filed in 2020 as well as 34 Re-Identification requests forms. All 902 legacy PI number assignment forms were uploaded which document requests dating back to 1997.

Eighty-one field books, NC7 Horticulture Plant Descriptions files, and numerous files from curator's files were digitized in 2020. All new documentation, including passport files are being digitally maintained. We recorded important identifying information (Accession, Received Date, etc.) from the documents in Excel file format. The Excel files will enable us to rename files en-mass to conform to document naming conventions that more easily support future upload to the GRIN-Global database.

D. Order processing (S. Estrada)

The GRIN-Global public website has improved accessibility to germplasm information and the ability to search for desired crop characteristics. This year, the order processing team continued to refine the use of GRIN-Global order actions, attachments, and local order numbers in conjunction with Excel workbook templates to monitor order progress, streamline processing, and inform internal and external cooperators of order status. Order actions allowed both NCRPIS teams (curatorial personnel, seed storage, pathology) and other NPGS personnel (i.e., APHIS, GRIN-Global feedback) to monitor a germplasm order more easily as it progresses through the pipeline towards fulfillment. Documentation related to orders is attached directly to the corresponding GRIN order via the Order Wizard's attachment tab, thus accessible to internal NPGS users. External users may also add attachments (usually an import permit, shipping instructions, or Excel file request list) through their public website order history. These processing improvements are exceptionally useful for communication and management of additional documentation that is required for international germplasm distribution.

During 2020, 3,146 orders were entered into GRIN-Global. 3,163 orders containing 93,122 items were processed. Of these, 2,728 entered the order processing system via the GRIN-Global Public Website. This year, there was an abnormally high proportion (52%) of non-research, non-educational (NRR) orders submitted for consideration. About 2,900 orders containing 80,000+ items were processed in 2020. A detailed summary of NCRPIS distribution activity is summarized in the table below which illustrates various internal use purposes, and in Appendix Table 3. Over 45,000 items were shipped to external cooperators even though order processing capacities were diminished beginning in March as a result of the COVID19 pandemic.

2020 - NCRPIS Germplasm Distributions Summary

		Grand Total					Distributed				
		Orders	Orders (%)	Order Items	Items (%)	Avg. Items per Order	Orders	Orders (%)	Order Items	Items (%)	Avg. Items per Order
External	Distribution	1,198	41%	54,167	57%	45	1,119	98%	45,436	77%	41
	Non-research, non-educational	1,684	58%	25,661	27%	15	2	0%	5	0%	3
	Observation / evaluation	15	1%	275	0%	18	15	1%	275	0%	18
	Repatriation	5	0%	22	0%	4	5	0%	22	0%	4
	Total	2,902	100%	80,125	85%	28	1,141	100%	45,738	77%	40
Internal	Backup	65	22%	3,702	4%	57	63	22%	3,650	6%	58
	Germination	134	44%	7,176	8%	54	132	45%	7,162	12%	54
	Phytosanitary Testing	37	12%	1,552	2%	42	36	12%	1,500	3%	42
	Replenishment/regrow	63	21%	1,750	2%	28	57	20%	1,103	2%	19
	Transfer	3	1%	9	0%	3	3	1%	9	0%	3
	Total	302	100%	14,189	15%	47	291	100%	13,424	23%	46
	Grand Total	**3,204**	**100%**	**94,314**	**100%**	**29**	**1,432**	**100%**	**59,162**	**100%**	**41**

Shipped orders:
A total of 2,902 external orders were processed. Of these, 1,141 (39%) were shipped and 1,756 orders were cancelled. External orders were cancelled for a variety of reasons including: 1,682 (58%) were NRR, 40 requestors were unable to secure an import permit, and 46 for other reasons such as mistakes, duplication, NCRPIS was unable to satisfy phytosanitary restrictions, or lack of response activity from the

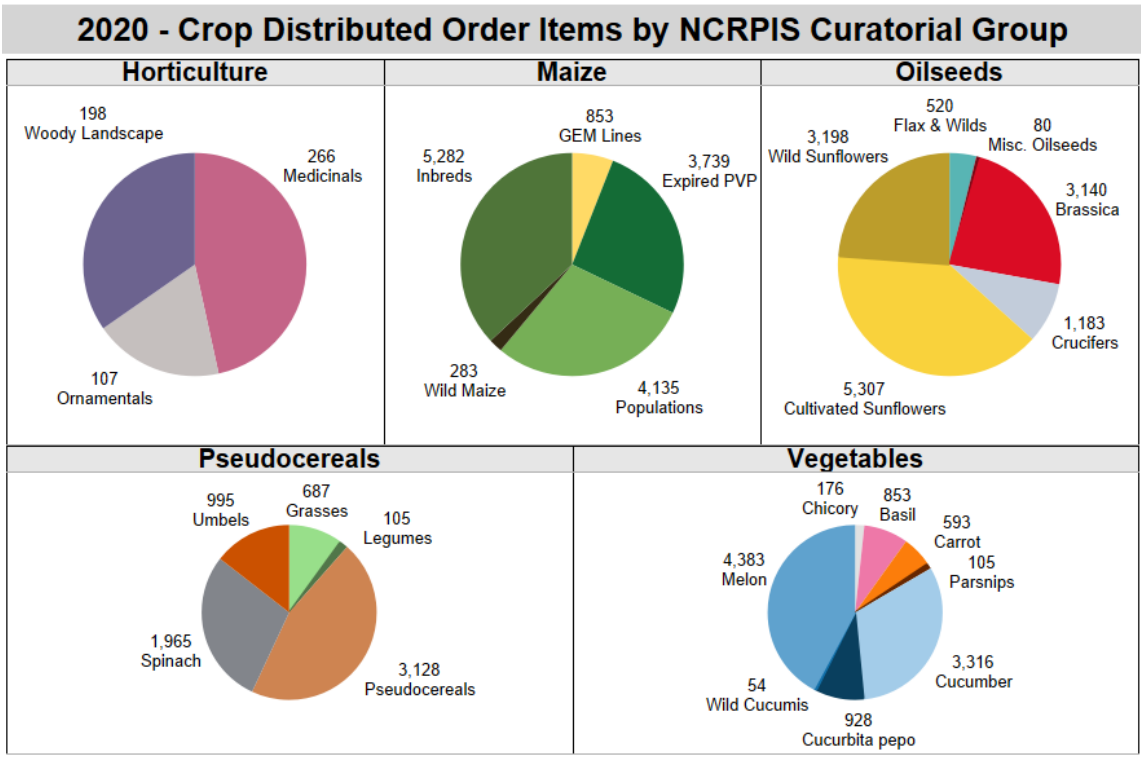
requestor for a year or more. The COVID19 pandemic completely or partially delayed all international distributions for most of the year.

Domestic orders accounted for 76% of all distributed orders and 46% of the distributed items (Appendix Table 3), indicating that U.S. requestors received fewer items per order. Maize was the most highly distributed crop within the United States. Multiple large orders for oilseeds and vegetable crops dominated international distributions including 5 extremely large requests for the sunflower (4,758 items), melon & cucumber (6,437 items total), and maize inbreds/populations (1003 items) collections.

2020 - NCRPIS External Germplasm Distribution Summary by Curatorial Group

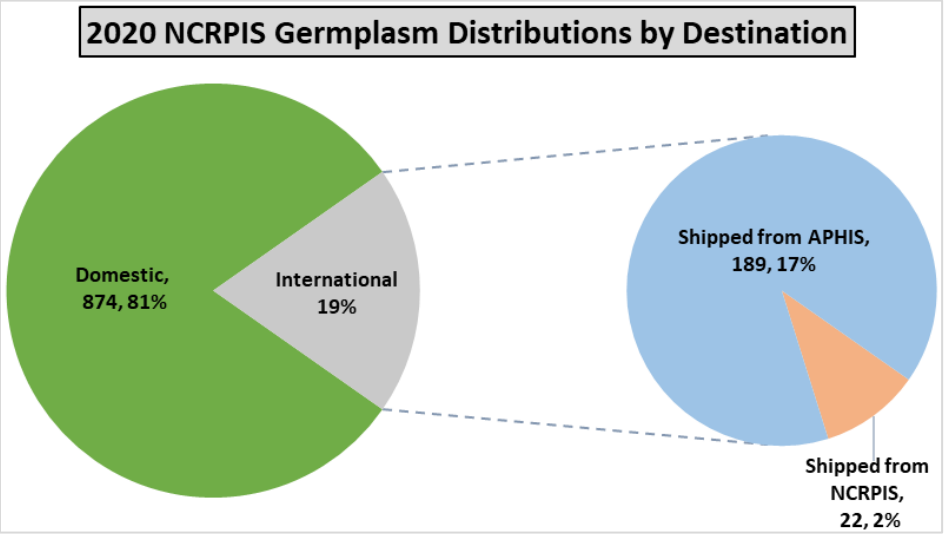
Curatorial Team	Orders		Order Items		Avg. Items per Order	
	U.S.A.	Int'l	U.S.A.	Int'l	U.S.A.	Int'l
Horticulture	97	9	424	80	4	9
Maize	449	88	9,396	3,835	21	44
Oilseeds	165	55	3,760	9,040	23	164
Pseudocereals	133	36	5,313	1,179	40	33
Vegetables	102	50	2,001	8,280	20	166
Grand Total	**853**	**219**	**20,894**	**22,414**	**24**	**102**

Order distributions were also summarized by curatorial group, as seen in the pie charts below. Oilseeds and Vegetable curatorial groups saw high demand for a few crop maintenance groups while Horticulture, Maize, and Pseudocereals requests were more balanced across crop groups.

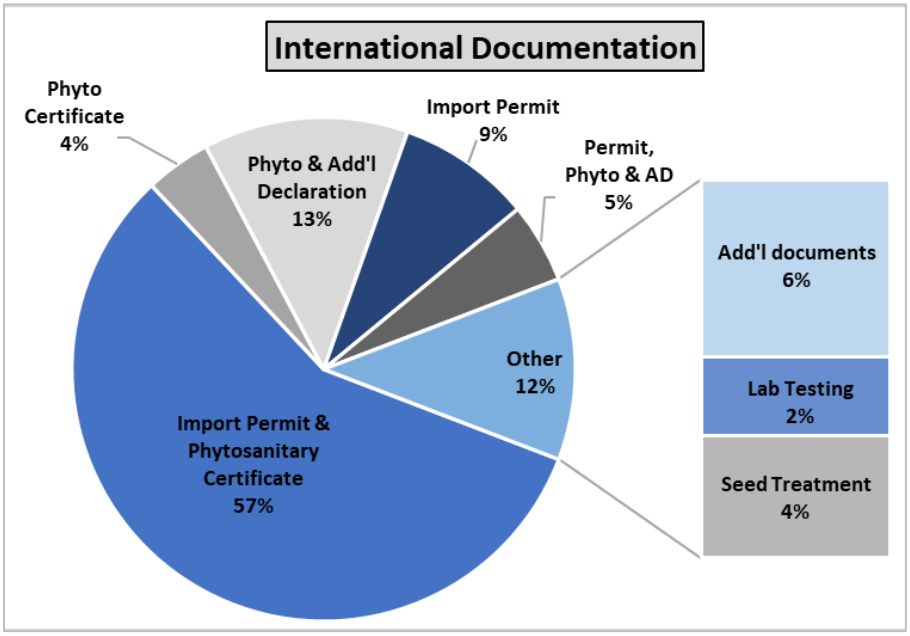


International orders accounted for 24% of those shipped and for 54% of all distributed items. Approximately 4 out of 5 international requests were transferred to APHIS in Maryland for phytosanitary certificate issuance prior to export. International orders shipped through APHIS/Beltsville.

For a more detailed view of orders, distributed external orders are visualized in the context of destination.



Each country has unique restrictions regarding the importation of plant material. Therefore, a considerable amount of effort and documentation is required to process these international requests. We adapted the local order number field to distinguish shipping destination as well as serve as a 'quick reference' for documentation and additional quality assurance needed prior to dispatch of an order.



The order processing team was busy this year with many large requests for international germplasm distribution. Almost ninety percent of all international orders required issue of a phytosanitary certificate prior to export and 40% of international distributions were shipped with an import permit. Import permit restrictions vary in complexity.

E. Seed Storage (L. Burke, A. Sonner)

The seed storage area was staffed by two full-time, permanent federal employees (Lisa Burke and Ashley Sonner), and three part-time student employees during 2020.

We stored 2,471 inventory lots, including 1,180 original seed lots. Of the increase lots, 774 were produced in Ames and 262 were produced outside of Ames. Across all stored inventory seed lots, we sampled and reviewed seed quantities of 3,940 lots, and any discrepancies with GRIN information were corrected in the GRIN database. We prepared and transferred 892 samples to the -20C freezer for long-term storage.

We filled 1,092 seed orders in 2020, including those for distribution, observation, germination, transfer and backup. The NCRPIS distributed 40,422 packets to meet distribution and observation requests. There were 1,694 lots sent to the National Laboratory for Genetic Resources Preservation (NLGRP) for backup, involving both accessions new to the NLGRP and additional seed quantities for previously deposited accessions. 2008 accessions were packaged for shipment to Svalbard.

With the aid of our student workers, we prepacked 55,393 packets from 5,372 inventory lots. Prepacking increases efficiency of seed storage operations by speeding up order fulfillment and also helps keep the on-hand inventories more accurate. Prepacking also reduces the need to review total seed counts for individual accessions because distribution lots are continually monitored and only reviewed when order activity is high for a given accession.

In 2020, 450 accessions received PI numbers and 1,124 inventory samples were relabeled and moved to the chronologically correct location.

Ashley Sonner began imaging original samples in 2020. She reviewed the original samples that were still pending imaging and has started scanning and uploading these using the attach wizard in GRIN Global. Using Danny Barney, Ph.D., handbook entitled, “Imaging Methods for High-Definition Close-Ups of Seeds and Other Plant Parts” as a starting point, 4 methods were implemented. 567 original samples were scanned in 2020.

Curatorial Group	Original samples imaged
Vegetables	88
Oilseeds	14
Horticulture	218
Pseudocereals	246

Figure 1. Example of small seed protocol (above)
Figure 2. Example of large seed protocol (below)

Lisa Burke continued to participate in the development of GRIN-Global. She served on the GRIN–Global Advisory Committee as chairperson. She chaired 21 meetings in 2020, each running between 1 and 2 hours. During the meetings, progress on curator tool and public web site enhancements were discussed, priorities were established, and the functionality of new software products verified. Continued focus was made on clarifying codes and adding descriptions for proper code usage.

Lisa Burke continued as the station's CPR/AED/First Aid instructor. She provided training for two-year CPR/AED/First Aid certification to 15 NCRPIS student workers and 10 staff members. Due to Covid-19, these classes were conducted online with skills certification completed in a socially distance setup to comply with the pandemic situation. Each session was entered into the National Safety Council database and certificates of completion provided for each participant. Cooperative efforts with campus staff to improve the CPR/AED/First Aid training continues.

Lisa Burke participated in several outreach activities related to STEM and seed saving activities for 4H, home gardeners and Native American farmers. As leader for the Boone County Science and Tech club she guides club members in STEM activities.

F. Germination (L. Pfiffner)

The germination lab was staffed by one full-time federal employee (Lisa Pfiffner) and up to three part-time student employees.

In 2020, the germination lab completed germination or Tetrazolium (TZ) testing on 165 orders containing 7,707 accessions.

Type of Order	Number of Orders	Number of Accessions
Regeneration	58	1,053
Maintenance	55	5,308
Original	30	1,120
Re-germ	20	202
TZ	2	24
Experiment	0	0
Observation	0	0
Total	**165**	**7,707**

The following table shows how many accessions were tested at regular amounts, 200 seeds, and how many at reduced amounts, 20-100 seeds. Conducting maintenance tests at reduced amounts was started in 2019. This helps increase testing capacity (number conducted per year), which helps to decrease the backlog of accessions needing to be tested, conserve germplasm and other resources.

Curator	Accessions tested at regular amount - 200sd	Accessions tested at reduced amounts	Total
Millard/Bernau	1,127	2,747	3,874
Brenner	445	638	1,083
Carstens	163	50	213
Marek	329	669	998
Reitsma	246	1,360	1,606
Total	**2,310**	**5,464**	**7,774**

Several webinars put on by Association of Official Seed Analysts (AOSA) were attended in 2020. This is continuing education to maintain certification to stay in good standing. The annual AOSA/SCST (Society of Commercial Seed Technologist) was cancelled this year due to the pandemic.

Germination protocols are based on AOSA protocols and from the Handbook of Seed Technology for Genebanks. If a taxon is not found in either of these references, then protocols are researched and devised for that genus/species. In 2020, 33 protocols were created or modified. Modified protocols are protocols that existed in the current format but were edited or added to in some way. Most of the modifications were

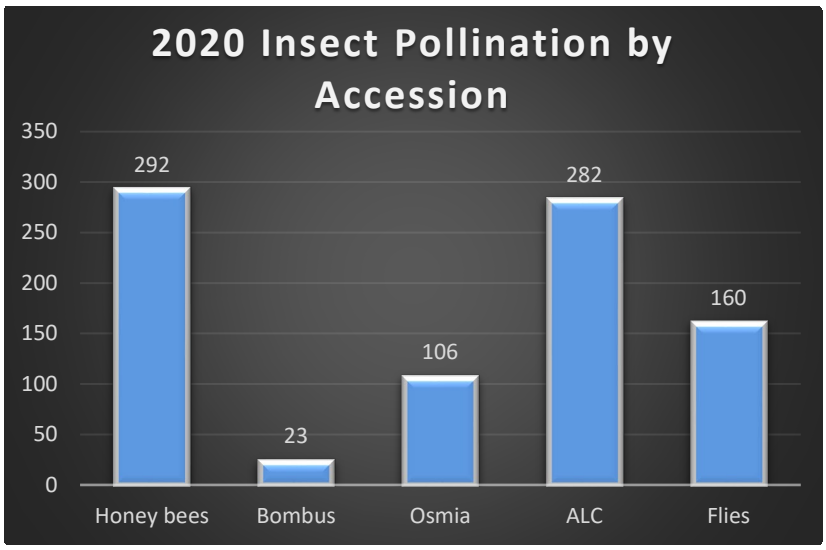
adding the number of replicates and seeds, i.e., 2 reps of 25. Format errors were corrected. Created protocols are protocols that were created for new or newly tested genus.

Protocols	Taxa tested
15 modified	*Alyssum, Camelina, Cichorium, Crambe, Eruca, Helianthus annuus, Lepidium, Melilotus, Monarda, Rhus*
18 created	*Calamovilfa, Cycloloma, Dysphania, Ferula, Oenanthe, Orlaya, Phacelia*

VII. CURATORIAL AND SCIENTIFIC TEAM REPORTS:

A. Controlled Insect Pollination Service Program (S. Hanlin, K. Judson)

Overview:
A total of 919 curator requests for insect pollinators were supplied throughout the pollination season. This number does not include the multiple periodic resupplying of alfalfa leaf cutting bee (ALC) or flies that were added on a weekly basis, only the single request. The figure below displays the total number of insect pollinator services provided. Bee pollinators (minus the ALC and dipterans) were supplied a single time to 464 accessions for controlled pollination of plants in 926 cages.



ALC and fly-pollinated cages are tabulated and reported separately due to multiple distributions of those insects to the same cages over the pollination season. Every cage received ALC and flies at least once. ALC and flies were used on similar plant types, and in the summer both Blue Bottle Flies and Common House Flies were introduced together.

Osmia are used in both the greenhouses and field cages and work best in early spring or the "cooler greenhouse" when temperatures are between 50-70˚ F. The average nesting period for Osmia is between 6-12 weeks. At the end of the pollination season,

Osmia domiciles are collected, and individual pupae are counted and used the following year.

Bombus colonies are used throughout the summer on plants with larger flowers. Because bumble bees are a more efficient pollinator, they need to be in cages for a shorter time period and a single Bombus colony can be used in numerous cages throughout the summer.

Because we are more proficient at managing honeybees, and because they are so successful as a generalist pollinator, they are the most highly used pollinator at the station. We can use a nucleus hive in multiple cages throughout the pollination season, but in general a nuc is left in a cage until pollination is done. Feeding of high fructose corn syrup is required on a weekly basis for honeybees and a pollen patty mix every other week for continual brood production.

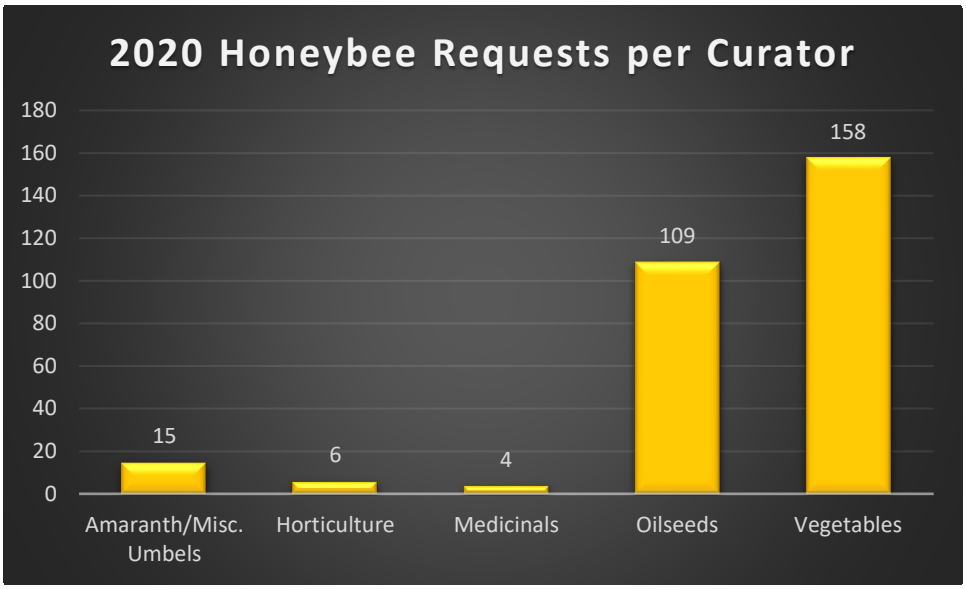
Health requests were made by the entomology crew or other curators throughout the summer in Bombus and honeybee colonies. Colonies failed for multiple reasons: queen failure, weakened hive, age, damage, etc. Once notified or observed, the colony was replaced to maintain pollination in that cage. There were 34 honeybee health requests and 16 Bombus requests during the pollination season. These numbers are not shown in the graphs as that would be misleading to the total number of cages per curator.

Total cage numbers are not included in the following graphs or charts, because of duplicate plantings, multiple nucs per cage or accessions which were relocated from greenhouse to field. A total 926 cages with 863 accessions had insect pollinators supplied to them throughout the pollination season. The graph below displays the total number of accessions pollinated per project.

Honeybee Pollination:
Honeybees were used to pollinate 331 cages in the field including health requests and duplicate accessions (some accessions require multiple cages). The following table does not include health requests or duplicate accessions, only single honeybee requests.

2020 Honeybee Pollinator Deliveries to Regeneration Cages

Crop Group	Total # of Accessions	# of Genera	# of Accessions/Genera
Misc. Umbels	15	6	*6 Pimpinella, 3 Anthenum, 2 Foeniculum, 2 Melilotus, 1 Angelica, 1 Carum*
Horticulture	6	4	*3 Cornus, 1 Anemone, 1 Caragana, 1 Spiraea*
Medicinals	4	2	*3 Hypericum, 1 Agastache*
Oilseeds	109	1	*109 Helianthus*
Vegetables	158	5	*90 Cucumis, 38 Cucurbita, 21 Cichorium, 8 Daucus, 1 Pastinaca*
Total	**292**	**18**	



Overwintering success:

All but seven three-story hives were left outside during the winter 2019/2020 at three locations and were wrapped with forty-pound roofing paper. Ten three story parent colonies were located at the NCRPIS in a fenced, secure in area designated for hives and 23 three story parent colonies were stored at two other locations (10 and 13). Approximately 13% of the outside colonies were lost prior to wrapping them. We placed into the overwintering room 21 two story parent colonies, 7 three story colonies and 60 double story nucleus hives. It was observed that 19% of the double story nucleus hives were lost prior to putting them into the indoor facility and 9% of the parent colonies were lost prior in the fall of 2020. All parent colonies stored inside were removed from the room starting on March 15th, and all outside colonies unwrapped on March 21st. The nucleus hives were removed from the over-wintering room on March 15th. In the winter of 2019/2020, 64% of the 33 wrapped, three-story colonies left outside survived, 64% of the inside colonies survived and 33% of the 60 double story nucleus colonies stored indoor survived. While the hives were in the over-winter room, they were fed a syrup/sugar patty combination in February and March to improve their survival in the spring.

We purchased 30 five frame nucleus hives from a local supplier, 30 three-pound bee packages from two local beekeepers (15 packages each) and 50 Italian queens from a California supplier. These were used to supplement over-winter losses and to supply spring nucs used for cage pollinations. The queens arrived by USPS mid-April, the packages were picked up and put into full size equipment in early May, and the nucs were placed into full size equipment prior to pick up in May. The hives were given three feedings of high fructose corn syrup (HFCS) and two pollen patty treatments during the buildup period. The purchased queens were placed into nucleus boxes with two frames of brood and a single frame of honey and adhering bees. All 50 queens survived and were used for nuc production. In early May we selected six resilient, over-wintered parent colonies and set them up as "cell builder colonies" for queen production during the summer 2020. However, during the summer one of the hives became weak and was switched for a stronger colony. The first graft was done on June 1st and produced 60 queen cells. This number is above average and made a healthy start for the summer. Throughout the summer, queen cell production was above 50 cells per week, and we ended grafting in early August. In 2020, likely because nucleus hives were purchased locally, we had no aggressive bee issues.

All nucleus boxes which were not used in cages for pollination were fed HFCS, an additional super was added, and bees were promoted to stock up with pollen and honey for winter survival. These nucs were treated for mites to prepare them for over-wintering. For winter preparation, all hives will be fed both syrup and a mixture of granulated sugar and corn syrup into late November prior to being placed into the overwinter room or wrapped in tar paper (and remain outdoors). Most of the colonies and nucs went into winter heavier than in the fall of 2019/2020. Feeding will begin February/March of 2021 to assist with survival.

Based on local beekeepers counts, mite numbers were lower this last year. We chose not to sample hives prior to applying mite treatment to hives. In late September and October, all colonies and double nucleus hives were treated with Formic Acid (Mite Away Quick Strip®) to prevent any varroa mite build up over the winter.

Starting in March through early April, all parent colonies and nucleus hives were given four feedings of HFCS. In October to mid-November, all hives were fed weekly into December all hives were fed a sugar patty weekly. In 2020, the medication used

to treat dysentery (nosema) Fumagilin – B® was not available, so all feedings were non-medicated. In December, Fumagilin – B® was purchased and will be used for spring medicated feeding. During the summer neither European Foul Brood (EFB) nor American Foul Brood (AFB) were observed.

As with the past four years, for wax moth control during the summer, all stored (unused) supers with "cleaned" frames were stacked at right angles to each other to prevent adult moth migration in the equipment room. Starting in June through September, the lights in the equipment room were left on during working hours (8 hours; five days). Unlike in the past, all equipment removed from the field as "dead hives" was placed in the back room of the shop. Next year, all "dead hive" equipment will be properly sorted and stored in the over wintering room to avoid moth build up and transfer to unused equipment.

The new tank system installed in 2019, proved to be more efficient, easier to maneuver, and we will continue to use the bulk tank in later years. We continued to use the 30-gallon poly "mixing" tank for filling feed containers. To prevent crystallization, insulated blankets were used to cover two tanks containing syrup and a tank heater was used in the third. On September 9th, 275 gallons of high fructose corn syrup were purchased for supplemental feeding during the summer and into the spring of 2021. We continued to use 5-gallon buckets in the spring and fall for refilling feed containers in the field to reduce container damage and syrup waste. The new feeding system using granulated sugar and corn syrup proved to be beneficial to the bees and was used in cooler months to encourage feeding.

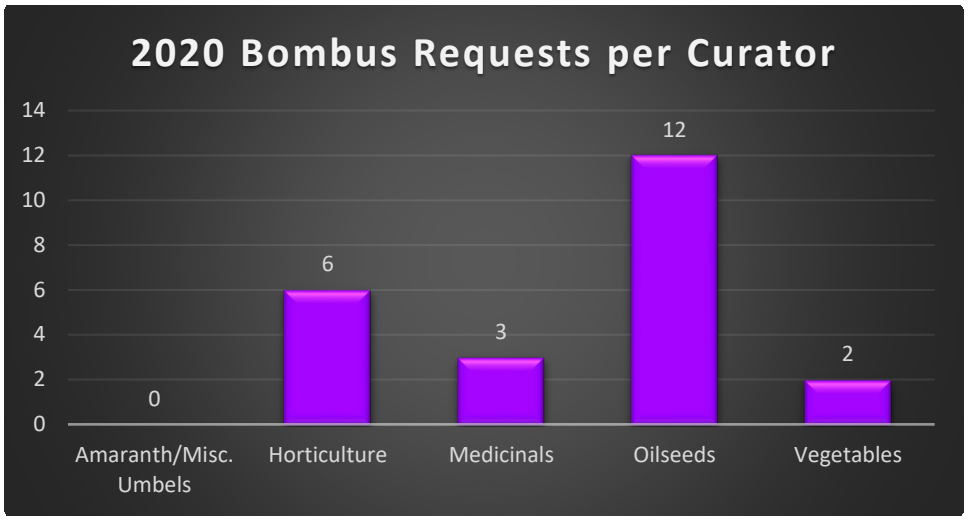
As in 2020, hive registration with the Iowa Department of Agriculture and Land Stewardship (IDALS) was done using "Field watch". Field watch allows you to register yards by plotting them directly onto Google maps. The locations only had to be confirmed in the system that they would continue to be used in 2021 to register them. The IDALS registry assists pesticide applicators in locating bee-yards and in obtaining contact information of appropriate beekeepers prior to spraying.

Bombus pollination:

Eighteen "mini-research" colonies of *Bombus impatiens* (bumblebee) were purchased from a commercial supplier. An additional two colonies were donated from the Horticulture Research Farm and used for pollination at the station. Bombus was used to pollinate 22 field cages. A single Bombus hive was used for pollinating more than one cage with a minimum lapse of 24 hours between sites to prevent pollen contamination. For some cages, loose worker bees refused to return to the hive and had to be retrieved by hand and released when the hive was switched to a different location. While in storage, we would place sugar-soaked cotton wicks into holding containers for bees to have a food source prior to release. In the Cucurbita and some *Helianthus* cages, because of the amount of vegetation, a single Bombus hive was combined with a honeybee nuc for more efficient pollination.

2020 *Bombus* Pollinator Deliveries to Regeneration Cages

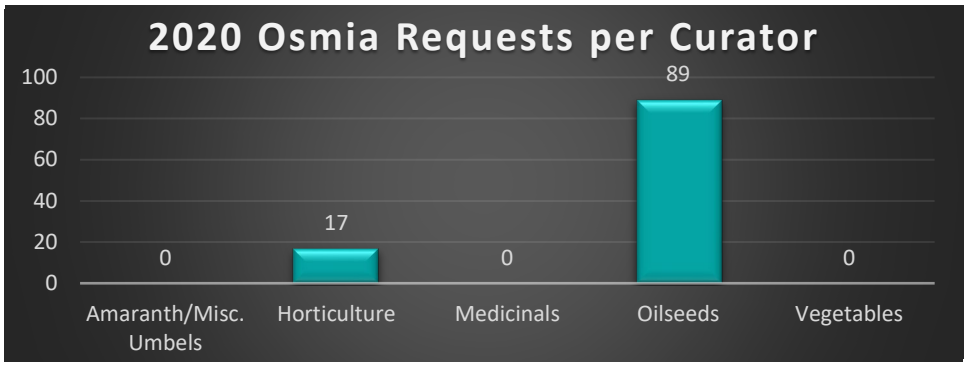
Crop Group	Total # of Accessions	# of Genera	# of Accessions/Genera
Horticulture	6	3	*3 Caragana, 2 Diervilla, 1 Viburnum*
Medicinals	3	2	*2 Monarda, 1 Hypericum*
Oilseeds	12	1	*12 Helianthus*
Vegetables	2	1	*2 Cucurbita*
Total	**23**	**7**	

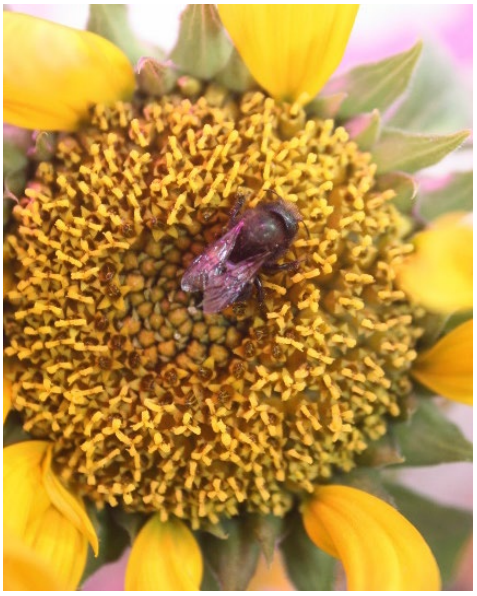


***Osmia cornifrons*/*O. lignaria* pollination:**
Osmia sp. were used to pollinate a total of 106 accessions in five fields and two greenhouses.

2020 *Osmia* Bee Pollinator Deliveries to Regeneration Cages

Crop Group	Total # of Accessions	# of Genera	# of Accessions/ Genera
Horticulture	17	6	*10 Aronia, 2 Cornus, 2 Salix, 1 Anemone, 1 Spirea, 1 Viburnum*
Oilseeds	89	6	*79 Brassica, 6 Camelina, 1 Centrapalus, 1 Crambe, 1 Erysimum, 1 Helianthus*
Total	**106**	**12**	





Osmia pupae (2,200) arrived on February 5th from a new supplier based in Idaho. Because adult bees had begun to emerge, there was some damage to the box, but it appeared that bees did not escape. In the spring of 2020, 110 Osmia domiciles were hung in greenhouse and field cages per request. An additional 30 domiciles were placed at a single "increase" site in hopes of collecting additional bees for the 2021 season. These domiciles are collected in mid-July to early August and stored in a refrigerator.

In November of 2020, Osmia tubes were sorted and counted. We collected approximately 489 pupae for use in the spring of 2021. Our numbers were lower than in the past year, possibly due to the dry weather conditions or from lack of a natural attractant spray that was used in 2020. From the increases alone, approximately 20-24 domiciles can be made. An additional 2,300 Osmia were ordered from the same supplier in Idaho and should arrive by mid-February of 2021.

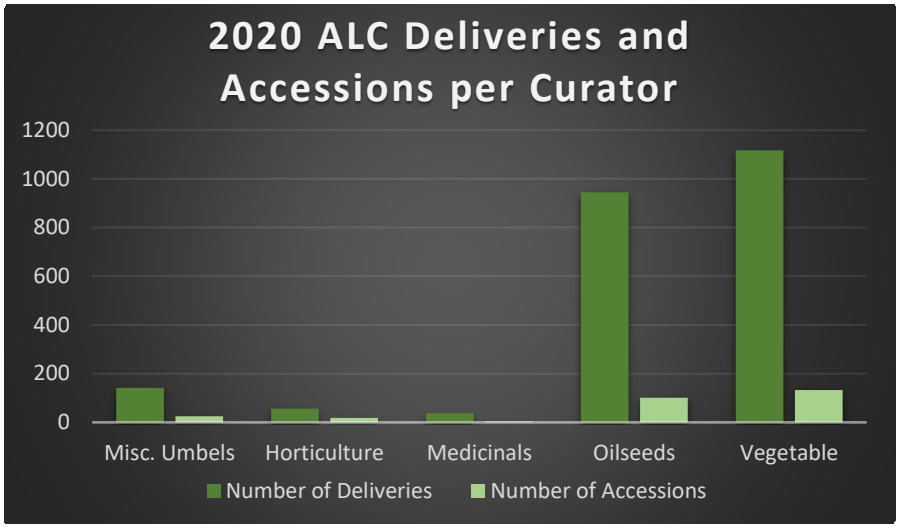
Alfalfa leafcutting bee (ALC) *Megachile rotundata*:

ALC bees were purchased as pupae in leaf cells from a single supplier for use throughout the 2020 pollination season over a variety of crops. Arriving on February 6th, the bee cells were held in a refrigerated storage unit until scheduled for placement in the warm incubation unit and bee emergence boxes. Bees were available weekly throughout the year for use in plant regeneration cages in the field and greenhouses from December 2019 into 2021. The 2020 pollinations were all completed using initially the last tubs of the 2019 cocoons and finishing with the 2020 cocoons for emergence of adults.

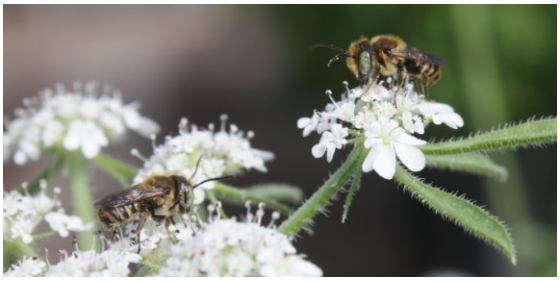
2020 Alfalfa Leafcutter Pollinator Deliveries to Regeneration Cages

Crop Group	# of Deliveries	# of Accessions	# of Locations	# of Genera	Time Period
Misc. Umbels	142	25	4	8	March – Dec.
Horticulture	57	19	6	5	March – Aug.
Medicinals	38	4	2	2	July – Sept.
Oilseeds	945	101	5	11	Dec. (19) – Oct.
Vegetables	1117	133	5	3	Dec. (19) – Oct.
Total	**2299**	**282**	**22**	**29**	**Dec. (19) – Sept.**

In 2020, 2,299 total ALC deliveries were made to a total of eleven fields and five greenhouses with 282 accessions containing 29 genera. A total of fifteen greenhouse cages were still receiving pollination services at the transition from 2020 into 2021.



Numbers of active ALC-supplied cages and the frequency of bee delivery vary seasonally and by cage structure/location and individual accession characteristics. In normal pollination situations, ALC bees/cells are only provided to crops in the field during the summertime months. However, at the station ALC are used outside of the normal time frame. From December 2019 through October 2020, greenhouse cages were supplied weekly with bees. The 2020 field requests for ALC bees started in late March and the number of weekly active cage increased through mid-August and then declined with the last field cages supplied through early-November.



In 2020, we received Canadian sourced cells, which have fewer parasites and parasitoids than found in U.S. cells. All ALC were stored in a Thermo-Scientific® environmental growth chamber (EGC) that was in operating order all summer.

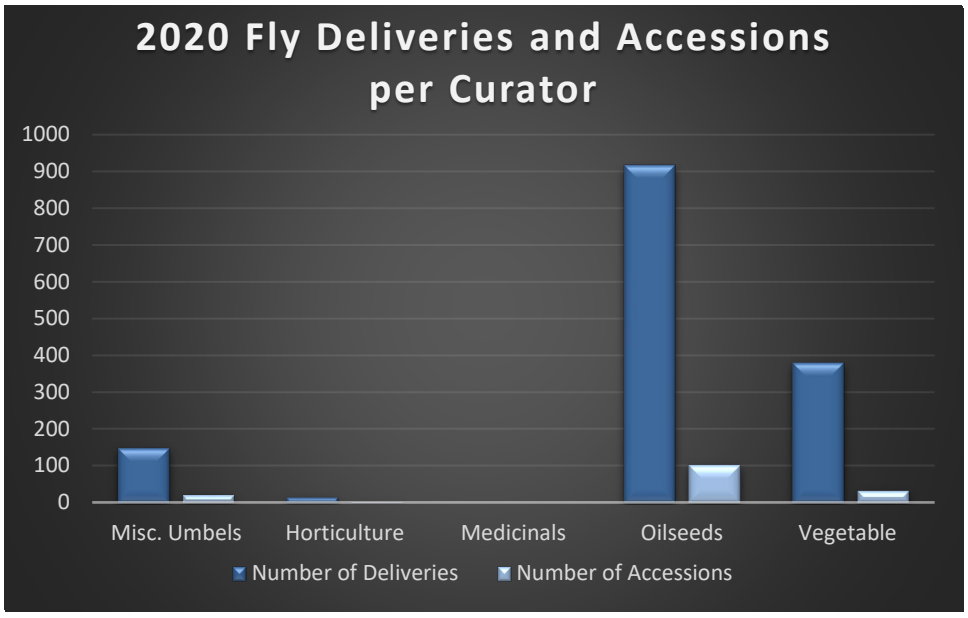
From September to early November, ALC were placed into cages of *Helianthus sp*, *Diervilla* sp, *Spirea* sp and several field vegetables cages. Under normal conditions ALC are not the major pollinator of some of these accessions nor are they used this late in the season in field cages. Because we had very few fall greenhouse pollinations but continued to emerge a low number of bees, we chose to place them into field cages rather than discard them.

Flies (Blue Bottle Flies and Houseflies):
Fly pupae of two species (*Calliphoridae sp.* and *Musca domestica*) were purchased from two suppliers and incubated for weekly use from mid-December 2019 through mid- October 2020 for greenhouse and field pollinations. From June through August, 13 orders of 20,000 house fly pupae were purchased and from late December 2019

through mid-September 2020, 210 cups of blue bottle pupae were purchased. In 2020, 1,464 fly deliveries were made to seven fields and five greenhouses with 160 accessions, containing 22 genera.

2020 Fly Pollinator Deliveries to Regeneration Cages

Crop Group	# of Deliveries	# of Accessions	# of Locations	# of Genera	Time Period
Misc. Umbels	150	22	4	8	March – Oct.
Horticulture	16	3	2	1	May – Aug.
Oilseeds	917	102	5	11	Dec. (19) – Oct.
Vegetables	381	33	4	2	Dec. (19) – Oct.
Total	**1464**	**160**	**15**	**22**	**Dec. (19) – Oct.**



From December 2019 through October 2020, greenhouse cages were supplied weekly with flies. The 2020 field requests for flies started in early May and the number of weekly active cages increased through mid-August and then declined with the last field cages supplied through mid-October. Because blue bottle flies work better at cooler temperatures and more cage requests were for the cooler greenhouse, only blue bottle flies were distributed weekly during the winter, spring and fall. During the summer, both blue bottle flies and houseflies were distributed weekly to greenhouse and field cages for pollination. Adult flies are re-supplied weekly to cages to ensure continued pollinator presence. Most cages with fly pollinators introduced also have other pollinators present to assure flower pollination based on promotion of

insect competition. During the summer, if there was an excess of fly pupae available, flies were introduced to some accessions which lack favorable flowers for fly pollinators such as sunflower or melons. This decision was made by the curators and the entomology staff to fully utilize the fly pupae.

Branding equipment:

As a method for assisting in identifying the station bee equipment and a deterrent for equipment being stolen, all woodware is branded with an identifying stamp displaying that the hives are property of USDA, ARS and providing contact information. In the winter of 2019/2020, all newly assembled foundation frames were branded, an activity which will continue in the future.

Safety:

Defensive Driving:

Because of the amount of time that the bee crew is off site and the number of cumulative miles during the summer, annual driving training was completed on AgLearn by both full-time entomology crew members to refresh on good driving habits and eliminate possible auto accidents.

Epi-pens:

In Mid-March, K. Grooms (nurse at ISU Occupational Medicine) was contacted about replacing expired Epi-pens and approval of the Epi-pen training on "the signs of anaphylactic shock and the correct use of Epi-pens". Because present pens did not expire until October 2020, it was decided by S. Hanlin and Grooms to not replace pens immediately. In late September pens were replaced. The issuing of the new pens is on the stipulation that training be completed in the spring by PI staff prior to possible need. Grooms stated that it is possible that ISU Environmental Health and Safety (EH&S) will have completed a PowerPoint presentation on anaphylactic shock and pen use by the spring of 2021. This training will take the place of the video found on the Epi-pen website which has been used in the past for training purposes.

Plans for 2021:

A mixture of HFCS and granulated sugar was applied to all overwintering nucs and colonies inside and outside of the overwintering room in 2020. More candy board frames were made for all colonies and will be applied onto the hive in early February to ensure spring survival. Multiple rounds of this mixture will be applied onto nucs by placing the mixture onto newspaper as the main feed source. The sugar mixture is neither liquid nor solid and is easy for the bees to consume. The idea is that the moisture and heat given off from the cluster of bees helps soften up the candy, located above the bees and enabling them to consume it easier.

Additional:
In the fall of 2019, all pollinator activities were videotaped by IT staff. Because most of the honeybee work was completed by that time and no active hives were used in the filming, in the summer of 2020, the queen rearing, and nucleus production activities were filmed and documented by K. Judson. In the winter of 2021, each of the sections for a specific pollinator will be made into a full-length video so that it can be used for training new employees or referred too periodically. They may also be used for showing others station staff or visitors what pollinators and methods are used for cage pollination at the station.

B. Plant Pathology (A. Testen, N. Pal)

A. Testen departed NCRPIS in August 2020 for a USDA position in Wooster, OH.

Research:
Dry heat treatment and germination:
Bacterial Fruit Blotch (BFB), caused by *Acidovorax citrulli* (*Aac*), is an economically important disease of cucurbits. This pathogen is seedborne and infected seed is considered to be the most important source of disease outbreaks. Seed lots of *Cucumis melo* accessions transferred to NCRPIS from Griffin, Georgia in 1987 were found to be *Aac* contaminated in previous greenhouse grow-out assays or field plantings. Our objective was to identify a seed treatment that would be effective in eradicating this bacterial pathogen from naturally contaminated seed lots in order to provide clean seed for distribution. Dry heat may be a potential seed treatment for eliminating or reducing *Aac* contamination. To determine if dry heat treatment would significantly impact germination, *C. melo* (PI 321005 17ncai01) and *C. sativus* (mix of PI 390259 19ncai01 and PI 390256 19ncai01) seeds were subjected to five heat treatments (40:85: 40°C for 48 hours followed by 85°C for 72 hours; 40:95: 40°C for 48 hours followed by 95°C for 24 hours; 40:85:95: 40°C for 48 hours followed by 85°C for 72 hours followed by 95°C for 24 hours; 40:90: 40°C for 48 hours followed by 90°C for 24 hours; 40:85:90: 40°C for 48 hours followed by 85°C for 72 hours followed by 90°C for 24 hours).. Three 50 seed replications were set up for each treatment. Germination was assessed four- and eight-days following placement of treated seeds on blotter paper in germination boxes. Of the five regimes, only 40:85:90 had a significant ($p < 0.05$) negative impact on *C. melo* seed germination. Treatments were not assessed for their efficacy in reducing *Aac* contamination.

Antibiotic screening against *Acidovorax citrulli*:
Sensitivity of *Acidovorax citrulli* (*Aac*) strains WFB 9421, WFB 8908, AAC 974, AAC 3036, AAC 6081 and ATCC29625 to 12 different antibiotics (Doxycycline, Ceftazidime, Cephalexin, Chloramphenicol, Erythromycin, Meropenem, Nystatin, Polymixin B, Rifampicin, Streptomycin, Sulfamethoxazole and Trimethoprim) were assessed by Kirby-Bauer disk diffusion susceptibility test to identify antibiotics that could potentially be used to eliminate *A. citrulli* in melon seedlings. Seventy-two-hour old *Acidovorax* cultures grown on NBY medium suspended in sterile water were spread onto Mueller Hinton agar with 10 µg of antibiotic applied to the disk. Two replications per antibiotic per isolate were performed. Plates were incubated at 30°C for 24 hours

and the diameter of any zones of inhibition was measured using a ruler. All *Aac* strains were sensitive to Doxycycline, Trimethoprim, Sulfamethoxazole and Ceftazidime in comparison to all other antibiotics tested.

Unknown Pseudomonas pathogens from Turkmenistan melon:
Unknown bacteria isolated by Dr. Charlie Block from melon accessions: Ames 29538, Ames 29542, Ames 29553, Ames 29562, Ames 29565 and Ames 29584 of Turkmenistan origin were characterized by KOH test, LOPAT [levan production from sucrose (L), presence of oxidase (O), pectolytic activity on potato (P), presence of arginine dihydrolase (A), hypersensitivity reaction on tobacco (T)] tests, and fluorescence under UV light. Phenotypic characteristics and 16S rRNA sequencing identified these unknown bacteria as *Pseudomonas syringae* strains. Pathogenicity of the strains was confirmed on *C. melo* 'Aurora' seedlings.

Quinoa anthracnose:
Stem lesions characteristic of anthracnose disease were observed on plants of two quinoa accessions PI 510547 and PI 596293 grown in the field during summer 2019. Fungi were isolated from both accessions and isolates examined morphologically. Sequencing and phylogenetic analyses based on five loci (*ACT*, *GAPDH*, *CHS-1*, *TUB2* and ITS) identified the isolates as *Colletotrichum nigrum* and *Colletotrichum truncatum*. Koch's postulates were completed successfully with both strains indicating both were pathogenic on quinoa. This study is the first report of quinoa anthracnose caused by *Colletotrichum nigrum* and *C. truncatum* in the United States (Pal and Testen 2021).

Low germination in cultivated sunflower accessions:
A pilot study was conducted on three sunflower accessions: PI 509060 18ncai01 (53% germination), PI 664194 18ncai01 (51% germination), PI 642776 18ncai01 (42% germination) to determine whether low germination is the result of seed deterioration or the presence of seed-borne pathogens. Agar and blotter tests were conducted to look for seed-borne mycoflora. PI 343806 18ncai01 and PI 686638 18ncai01, all with 100% germination, were included for comparison. Electrical conductivity tests were performed using dehulled seeds. Results showed no difference in the mycoflora present on the seed lots with low or high germination. Whereas the electrical conductivity was significantly higher in the seed lots with low germination indicating electrolyte leakage and possible seed deterioration from membrane damage.

Phytosanitary Inspections of Seed Increases:
Phytosanitary inspections were conducted on 879 NPGS seed increases in 2020 (608 field increases and 271 greenhouse increases). In addition, phytosanitary inspections were conducted in 3902 GEM plots. The pathology team worked with curation teams to ensure that disease issues were diagnosed, and management recommendations provided in a timely manner. The number of accessions and total number of disease observations for phytosanitary inspections can be found in Table 1.

Table 1. Number of accessions and number of observations loaded to GRIN for 2020 for either field inspections or laboratory testing

	Phytosanitary inspections		Lab testing	
Crop	**# of Accs**	**# of Obs uploaded to GRIN**	**# of Accs**	**# of Obs uploaded to GRIN**
Grasses	24	34	0	0
Chenopods	71	71	0	0
Amaranth	96	96	0	0
Umbels, Legumes, & Misc.	81	81	0	0
Brassica	79	79	0	0
Euphorbia	0	0	0	0
Flax	6	6	0	0
Sunflower	82	565	45	180
Maize	201	2,233	1,461	3,016
Cucumis	98	686	96	96
Cucurbita	43	271	44	44
Daucus	11	11	0	0
Ocimum	0	0	0	0
Parsnips	1	1	0	0

Maize and GEM:
Phytosanitary inspections were performed for 183 field plots of maize and for 3,902 GEM plots. In general, disease severity was low in plots. Tar spot was not observed at the NCRPIS. No other diseases of key phytosanitary concern were observed (Stewart's Wilt, Goss's Wilt, viral diseases, and head smut). Eighteen accessions were inspected in the greenhouse.

Oilseeds:
Phytosanitary inspections were conducted for 127 sunflower plots. Apical chlorosis and downy mildew were not observed in early season scouting. No diseases of phytosanitary concern were noted. Greenhouse inspections were conducted for 30 accessions.

Flax increase plots (6), in general, had no disease.

For Brassica increases, no diseases of phytosanitary concern were observed 79 plots.

Vegetables:
Squash mosaic virus (SqMV) screening was conducted on 136 accessions prior to planting. No *Cucurbita* or *Cucumis* accessions tested positive for SqMV.

136 cucurbit, 22 chicory, 11 Daucus and 1 parsnip accessions were inspected for diseases in the field. For *Cucumis* and *Cucurbita* increases, disease severity was, in general, low and no diseases of phytosanitary concern were noted. Five cucurbit accessions were inspected in the greenhouse.

No diseases of phytosanitary concern were observed in *Daucus* and *Cichorium* increases.

Amaranthus, Chenopodium, Panicum, Setaria and Miscellaneous Apiaceae and Poaceae:
For phytosanitary inspections for the Amaranth curatorial crew, 106 phytosanitary inspections were conducted for winter greenhouse increases, 43 plot inspections were conducted for field increases, and 112 phytosanitary inspections for autumn greenhouse increases. For greenhouse and field inspections, no diseases of phytosanitary concern were observed.

Seed Health Testing:
In 2020, 3,016 ELISA tests were conducted on 1,461 maize seed lots, while bioassays, plating, or microscopic observations were conducted on 45 lots (all *Helianthus annuus*). A summary of seed health testing by accession and number of observations can be found in Table 1. This seed health testing supported 37 orders along with internal testing for the maize curation and GEM teams. Maize seed health testing was the main focus of testing with many international orders requiring testing for Stewarts wilt, Goss's Wilt, Maize chlorotic mottle virus (MCMV), and Wheat streak mosaic virus (WSMV).
Additional declarations were written in support of phytosanitary certificates for 96 orders.

Publication:
Pal, N. and Testen, A.L. 2021. First report of quinoa anthracnose caused by *Colletotrichum nigrum* and *C. truncatum* in the United States. Plant Disease 105:705.

C. *Amaranthus, Celosia, Chenopodium, Coronilla, Dalea, Echinochloa, Galega, Marina, Melilotus, Panicum, Perilla, Setaria, Spinacia* and miscellaneous *Apiaceae* and *Poaceae* (D. Brenner, S. Flomo)

Acquisitions:
We acquired 8 accessions: 1 *Amaranthus*, 1 *Cyclolma*, 5 *Dalea*, and 1 *Setaria*.

The *Amaranthus* accession (Ames 35286) is a herbicide susceptible bioassay standard for *Amaranthus tuberculatus* from the University of Illinois. *Cycloloma atriplicifolium* (Ames 35603) was collected by David Brenner to better represent this quinoa crop-wild-relative with edible seeds. The five *Dalea* accessions Ames 35544, 35548, 35555, 35556, and 35564 were obtained by Jeff Carstens and Andrew Sherwood to expand our holdings of these commercial landscaping species. The *Setaria*, Ames 35602, is an obscure wild variety, *Setaria viridis* var *major*, with brown bristles.

We received 201 accessions in 2019 or earlier and accessioned them in 2020. Dr. Eric Jellen of Brigham Young University donated 198 accession of wild *Chenopodium* collected in 2019 with Plant Exploration funding by the USDA/ARS, Plant Exploration Office, Beltsville, MD. They were accessioned in 2020 as Ames 35338 to Ames 35535. Two grain amaranth cultivars developed by Dr. Rob Myers in Missouri, 'Crimson Glow' and 'Golden Glow' were accessioned as Ames 35280 and Ames 35281,

and an *Amaranthus dubius* accession segregated from PI 482051 was accessioned as Ames 35609.

David Brenner segregated, a mutant dwarf form of *Chenopodium ficifolium* from an accession of normal *C. ficifolium* (Ames 34323) in 2019. This mutant (DB 2020666) has good seed set on plants that are short, stocky and have wider leaf blades than typical plants. Plants generated from propagated seed of the mutant exhibited uniform expression of the dwarf trait when grown in a winter 2020 greenhouse increase. This segregate will get a new accession number in 2021.

Collection Maintenance:

Spinacia:

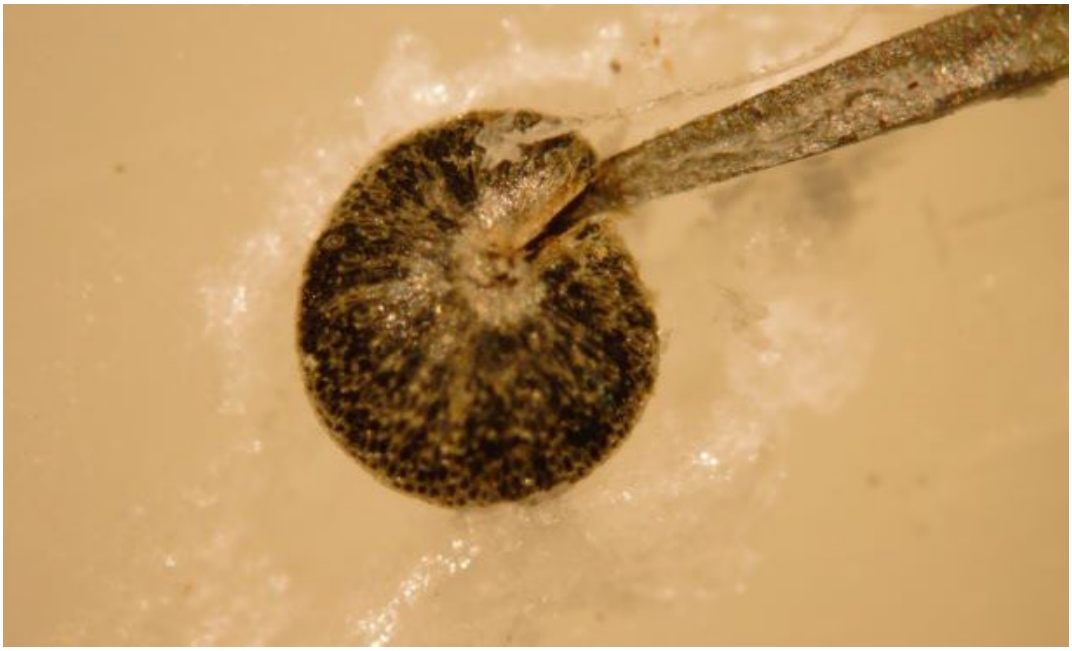
Our spinach regeneration cooperator, Beiquan Mou of the USDA-ARS in Salinas, California returned 15 seed lots of freshly regenerated spinach germplasm from harvests in 2020. Beiquan is growing 34 accessions of spinach for harvests in early 2021. One cultivated spinach accession was harvested from a field planting on the NCRPIS farm, and a wild spinach accession was planted in a greenhouse to harvest in 2021

Foeniculum:

Some difficult to regenerate fennel accessions are too long-season for seed production after direct seeding in the field, in our climate. They flower in late September and don't mature seeds before frost. In January 2020 we planted three of these long-season accessions in a greenhouse and transplanted them into the field. From this early start the plants flowered in time to for successful seed maturity in the field.

We are overwintering caraway plants in the field from 2020 to 2021 and protecting the plants from deer feeding with deer fencing shown below with K. Kapplemann our student employee. Most caraway accessions are biennial and winter-hardy in Iowa. The plants are expected to start growing in early spring and mature seeds in the summer.

Chenopodium:
We are growing many wild species of *Chenopodium* now that the entire genus is a research priority for improving *Chenopodium quinoa.* Seventy-three seed lots of wild Chenopodium were harvested in 2020. Our success propagating wild *Chenopodium* species has improved with a new dormancy breaking protocol involving cutting through the dormant seed's micropyle under a microscope with a scalpel.



A wild *Chenopodium* seed during a scalpel cut through the micropyle to release dormancy. These seeds are about 1 mm wide and are best worked on under a microscope.

Miscellaneous maintenance progress:
We had a successful 116-row amaranth observation planting in the field. Notes on field adaptation to Iowa conditions were added to GRIN. The field's alleys and an un-used area were planted with a 'GreenSugar MS' sorghum × sudangrass ground cover planted from commercial seeds, which grew well and persisted after mowing, making our field much less muddy than in previous years.

A new model of seed collection basket was purchased for the LT-20 thresher and works well. It has an O-ring for a tight fit in the thresher so fewer small seeds leak out and are wasted.

An upright plywood seed dryer was refurbished by C. Hopkins. The seeds now dry in faster forced air than in our older dryers, resulting in faster seed drying at the same temperature and (in theory) healthier seeds. Cole also refurbished the irrigation system in one of our greenhouse rooms with sturdy polyethylene pipes replacing aging garden hoses for a permanent system.

Characterization/evaluation/taxonomy:
The GRIN database was enhanced with updates listed below:

Updating GRIN 2020

Count	Name	Description
16	Taxonomic Re-IDs	Taxonomic changes were made in four genera. Twelve of the changes were in *Chenopodium*.
64	PI numbers	Permanent "PI" number identifiers were assigned to accessions with temporary Ames numbers. They include 25 *Melilotus* accessions and a mix of other genera.
123	Citations	Links to research publications were loaded onto cited accessions in GRIN.
3,307	Observations	Observations were loaded into GRIN for traits such as flower color, male sterility, and seed weight.
1,756	Images loaded	These include 284 images of seeds by Ashley Sonner as part of her process for storing new seeds.
508	Seed lots stored	Backlogs of harvested seeds dating back to the 2015 parsley harvests were made available for distribution in 2020.
16	Taxonomic Re-IDs	Taxonomic changes were made in four genera. Twelve of the changes were in *Chenopodium*.

Amaranthus:
A novel amaranth trait: red blank flowers and white seed-setting flowers, was noticed for the first time, by David Brenner in December 2020. Images of PI 538320 at the link below show this trait, which also occurs in other accessions. The white flowers have set seeds for normal seed production, but the red flowers are smaller and blank, meaning that they have not set seeds. This coloring creates a polka-dot color pattern across the inflorescence. Presumably the color contrast develops after pollination.

Link to PI 538320, *Amaranthus cruentus* L., K283 with images of the flower colors:
PI 538320 GRIN-Global (ars-grin.gov).

Taxonomic novelty:
Amaranthus accession PI 677087 was re-identified as our only accession of an unusual newly described species: *Amaranthus neei*, changed from the widespread taxon *Amaranthus hybridus*. We grew a small planting of PI 677087 this fall to make taxonomic observations and posted images on GRIN that were studied by the authors of the new species to confirm this determination. The new species has fewer and smaller tepals than *A. hybridus* but otherwise they look similar.

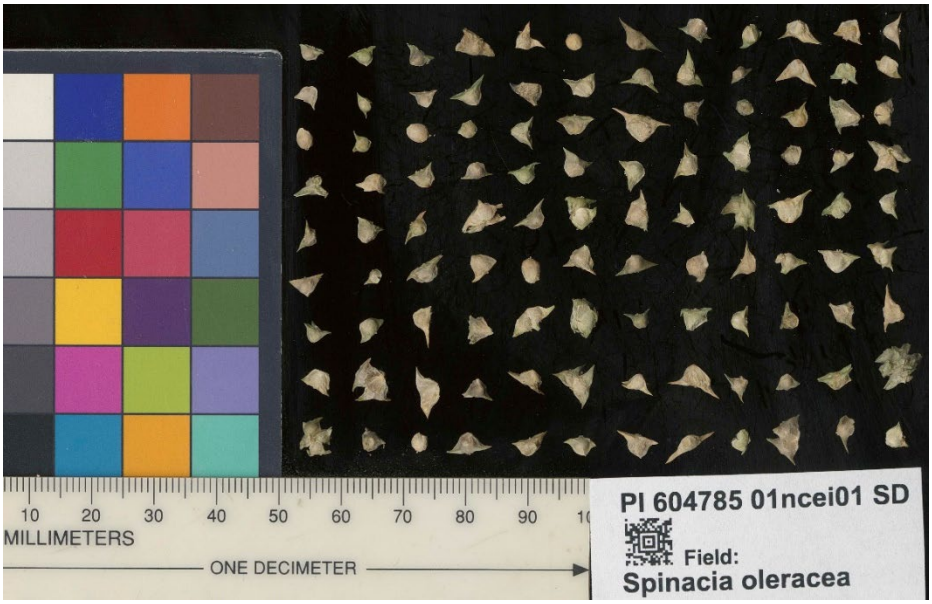
Link to PI 677087 *Amaranthus neei* with images:
PI 677087 GRIN-Global (ars-grin.gov).

Chenopodium:
White seeds from deciduous seeded coats: A white-seeded and historically documented grain *Chenopodium* from the Himalayan mountains was recovered from 2% frequency in a black seeded accession. Eight white seeds selected from the PI

658740 93ncai01 seed lot were planted in the fall 2020 greenhouse to segregate a white seeded line as described for grain Chenopodium diversity in India (Partap, T. 1985. Agriculture Ecosystems and Environment. 14:201–220). Two white seeded plants were segregated as 20ncai01. These white seeds are the result of vestigial or deciduous black seed coats (testas) exposing the underlying white perisperm and embryo. In 2021 we will grow 20ncai01 to study the stability of this unusual trait.

Freshly harvested seeds of PI 658740 20ncai01 have unusual deciduous seed coats.

Spinacia:
Our hourly crew members scanned all 412 of the spinach seed lots for distribution, and noted the frequency of seed spines, and of seeds in clusters. The scans and the observations are posted publicly in the descriptor part of GRIN.



An example of the new spinach seed scan images posted in GRIN.

A *Chenopodium quinoa* accession successfully set seed in our field planting. We planted an observation row of PI 634920 'Faro' in the 2020 field. Two plants out of 24 had good seed set which is unusual for our climate, seeds were harvested as DB 2020825. We intend to plant DB 2020825 in 2021 to see if this is repeated in the next generation.

Commercial development:
The new sweetclover cultivar 'Silver River' developed from our collections by Gerald Smith (Texas A&M) is available for sale by at least two vendors: Turner Seed Company and Justin Seed Company.

Surprisingly, *Dalea candida* and *Dalea purpurea* seeds are available from many commercial sources and seem to be increasing in popularity and are no longer obscure. They are often included in native plant restoration mixtures. I don't know if our germplasm is parental to the commercial seeds, but we have a collection of 138 *Dalea* accessions, 38 of which are available for distribution and investigation.

Outreach and Presentations:
A multi-year Proso Millet crop vulnerability project with Brad Morris and Dipak Santra concluded in June with a report (Brenner et al. 2020) that is now posted under the Forage and Turfgrass CGC on the USDA/ARS GRIN Crop Germplasm Committee web site.

David made presentations at two online crop conferences, a Washington State quinoa conference, and a Mexico City amaranth conference, cited below as Brenner 2020a and 2020b. David also presented twice during the NPGS PGOC Virtual Curator workshop: on operation of the Haldrup LT-20 thresher, and on male sterility research in the *Amaranthus* germplasm collection. He also reported during the NC7 Technical Committee meeting.

Crop Germplasm Committee reports:
Written progress reports were prepared for the Alfalfa and Clover, and New Crops, Crop Germplasm Committees.

Service:
As Past Crop Science Society C8 Division (Genetic Resources) Chair in 2019, David organized a committee to select the outstanding genetic resources paper published in Crop Science in 2018 and 2019, two years in a row.

David reviewed two journal articles and one grant proposal.

Promotion:
In August 2020 David Brenner was reclassified from Curator II to Research Scientist III in the new 2020 Iowa State University job classification system, a promotion recognizing his curatorial contributions.

Plans for 2021:

Cytoplasmic male sterility (CMS) in grain amaranths:

After releasing the first publicly available cytoplasmic male sterile amaranth (PI 686465) in 2019, CMS research was advanced by testing additional accessions to classify them as maintainers or restorers in crossing with the CMS amaranth. These observations are posted as descriptors in GRIN. Also, we began backcrossing CMS into cultivars. The F_1 generation CMS male sterile populations were experimentally restored to fertility with our standard restoring accession (PI 538323) with the surprising outcome of 100% lethality after excellent germination in two cases. These developments are summarized in Brenner (2020b).

Seedlings with the lethal trait germinate well but die post cotyledon stage. The bent stem is typical of these lethals. Image by Lisa Pfiffner.

Duplication in the Amaranthus collection:

There appear to be about 100 duplicate Amaranthus accessions from the Luis Sumar Kalinowski amaranth project that was active in Peru into the 1980s, as revealed by the LSK markers. For example, LSK 36 was accessioned as PI 490456 in 1984 and later in another donation as Ames 15087 in 1990. These possible duplicate accessions will be grown for side-by-side comparison and merged if the duplication is confirmed.

There appear to be about 50 duplicate Amaranthus accessions from the Luis Sumar Kalinowski amaranth project that was active in Peru into the 1980s, as revealed by the LSK identifiers. For example, LSK 72 was accessioned as PI 490655 in 1984 and later in another donation as Ames 15185 in 1990. These possible duplicate accessions will be grown for side-by-side comparison and merged if the duplication is confirmed.

Publications about our germplasm:

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Brenner, D.M. 2020a. Chenopodium genetic resources in the U.S. National Plant Germplasm System. In: International Quinoa Research Symposium. August, 17-19, 2020, Seattle, Washington. Online symposium, YouTube recording.
IQRS 2020 - Genetic Resources - David Brenner - YouTube

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https://amaranthgdb.org/popamaranth.html

Deb, S., S. Jayaprasad, S. Ravi, K. R. Rao, S. Whadgar, N. Hariharan, S. Dixit, M. Sunil, B. Choudhary, P. Stevanato, E. Ramireddy, and S. Srinivasan. 2020. Classification of grain amaranths using chromosome-level genome assembly of ramdana, *A. hypochondriacus*. Frontiers in Plant Science 11:579529 doi:10.3389/fpls.2020.579529

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Emrani, N., M. Hasler, D. S.R. Patiranage, M-T. Nathaly, E. Rey, and C. Jung. 2020. An efficient method to produce segregating populations in quinoa (*Chenopodium quinoa*). Plant Breeding 139:1190–1200. doi:10.1111/pbr.12873

Golicz, A.A., Steinfort, U., Arya, H., Singh, M.B., Bhalla, P.L. 2020. Analysis of the quinoa genome reveals conservation and divergence of the flowering pathways. Functional and Integrative Genomics. 20:245–258. doi:10.1007/s10142-019-00711-1.

Hoidal, N., S-E Jacobsen, A. Odone, and G. Alandia. 2020. Defoliation timing for optimal leaf nutrition in dual-use amaranth production systems. Journal of Science Food and Agriculture 100:4745–4755 doi:10.1002/jsfa.10533

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Tropical Agriculture, Food, Environment and Extension 19:11–17. doi: 10.4314/as.v19i1.2

Joshi, D.C., R.P. Meena, and R. Chandora. 2020. Genetic resources: Collection, characterization, conservation, and documentation. Pages 19–31, Chapter 3. In: Singh, M. and S. Sood, Eds. Millets and Pseudo Cereals. Woodhead Publishing Series in Food Science, Technology and Nutrition. Oxford, UK doi:10.1016/B978-0-12-820089-6.00003-3

Montgomery, J.S., D. Giacomini, B. Waithaka, C. Lanz, B.P. Murphy, R. Campe, J. Lerchi, A. Landes, F. Gatzmann, A. Janssen, R. Antonise, E. Patterson, D. Weigel, and P.J. Tranel. 2020. Draft Genomes of Amaranthus tuberculatus, Amaranthus hybridus, and Amaranthus palmeri. Genome Biology and Evolution 12:1988–1993 doi:10.1093/gbe/evaa177

Munir, H., T. Samreen, and A. Atta. 2020. Simultaneous selection of proline contents and panicle plant for evolution of high yielding quinoa (*Chenopodium quinoa* wild.) progenies in Pakistan. Journal of Agriculture and Food 1:11–21

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Sammour, R.H., M. Mira, S. Radwan, and S. Fahmey. 2020. Genetic diversity and phylogenetic relationships among and within *Amaranthus* spp. using RAPID markers. Revista Mexicana de Biodiversidad doi:10.22201/ib.20078706e.2020.91.3254

SpinachBase: http://www.spinachbase.org/ a new web site with spinach genome and transcriptome resources managed by Shanghai Normal University and Boyce Thompson Institute.

Szabóová, M., M. Záhorský, J. Gažo, J. Geuens, A. Vermoesen, E. D'Hondt, and A. Hricová. 2020. Differences in seed weight, amino acid, fatty acid,oil, and squalene content in -irradiation-developed and commercial amaranth varieties (*Amaranthus* spp.). Plants 9:1412 doi:10.3390/plants9111412

Vorsah, R.V., B.N. Dingha, H. Sharma, and L. Jackai. 2020. Evaluation of biorational insecticides as stand-alone treatments for the management of the pigweed flea beetle, *Disonycha glabrata* (Coleoptera: Chrysomelidae), in organic production of *Amaranthus* spp. Sustainable Agriculture Research 9:58–70 doi:10.5539/sar.v9n3p58

D. Horticulture (J. Carstens)

The Horticulture project currently holds 3,926 accessions representing 190 genera (Table 1.0). Significant NC7-medicinal collections include: *Actaea* (44), *Agastache* (96), *Echinacea* (197), *Calendula* (83), *Hypericum* (226), *Monarda* (165), *Prunella* (54), and *Tanacetum* (54). Significant NC7-ornamentals collections include: *Alcea* (34), *Malva* (55), *Phacelia* (53), *Potentilla* (127), *Sphaeralcea* (90), and *Thalictrum* (52). Significant NC7-woody landscape collections include: *Aronia* (106), *Betula* (170), *Cornus* (205), *Euonymus* (60), *Fraxinus* (508), *Gymnocladus* (89), *Rhus* (100), *Salix* (61), *Spiraea,* (104), *Staphylea* (45), and *Ulmus* (44). Jeffrey Carstens is serving as curator and Andrew Sherwood as technician.

Table 1. Active accessions maintained in the NC7 horticulture collections (medicinals, ornamentals, and woody landscape) as of December 31, 2020

Management group	Genera	Accessions
NC7-medicinals	35	1,113
NC7-ornamentals	56	775
NC7-woody landscape	99	2,038
Total	**190**	**3,926**

Acquisitions:
During 2020, we acquired a total of 57 accessions including 29 medicinal, 8 herbaceous ornamental, and 20 woody landscape accessions to the horticulture collections. An additional 25 acquisitions were also acquired in collaboration with William Johnson with the Iowa Department of Natural Resources Prairie Resource Center to acquire germplasm of herbaceous perennials from Iowa remnant prairies. These accessions were transferred to appropriate NPGS repositories including the Ornamental Plant Germplasm Center of 15 accessions of *Asclepias* (1), *Baptisia* (1), *Liatris* (5), *Phlox* (1), and *Verbena* (7) and the Western Regional Plant Introduction Station of five accessions of *Amorpha* (4) and *Glycyrrhiza* (1) and also five accessions of *Dalea* to NC7 curator David Brenner.

Significant contributions from other cooperators included collections by Kurt Hansen with the USFS of accessions of *Amorpha* (3), *Agastache* (4), *Lycopus* (1), *Sporobolus* (1), *Geum* (1), and *Vitis* (1) and by Wyatt Williams with the Oregon Department of Forestry of eleven accessions of *Fraxinus latifolia*.

Targeted acquisitions were focused on collecting *Agastache* (12) in Minnesota (5), Montana (4), South Dakota (1), New Mexico (1), and Nebraska (1); *Monarda* (12) in Tennessee (2), Illinois (1), Pennsylvania (6), Michigan (1), Kansas (1), and Missouri (1); *Stachys* (3) in Iowa; and also *Salix* (2) in Iowa and Wisconsin.

A collaboration with the Iowa Department of Natural Resources was initiated with the goal to sample *Pinus strobus* from remnant specimens in Iowa. Initial work resulted in the acquisition of two accessions. The goal of this project is to eventually create a seed orchard utilizing only Iowa ecotypes to supply germplasm for future restoration projects.

Acquisitions of *Agastache foeniculum* in 2020 merit recognition as these were collected in Montana (3) and Nebraska (1) by Kurt Hansen (USFS) and Justin Evertson (Nebraska Statewide Arboretum), respectively. The species is tracked by the National Heritage Programs in each state where the species is currently under review and is listed as S1 (critically imperiled) in Montana and Nebraska, respectively. Potentially only a few remnant populations remain in each state.

Maintenance:

Regenerations:

Existing plantings that mostly consisted of *Aronia, Betula, Hypericum,* and *Spiraea* were harvested via controlled pollinations. A total of 33 accessions were increased. Statistics in Table 2.0 (Number Harvested Regen) also include the number of leaf tissue samples harvested to serve as potential distributions to cooperators interested in genetic analysis as opposed to depleting seed inventory.

We attempted germination for future regeneration on 39 accessions focused on *Aronia, Betula, Hypericum, Salix,* and *Spiraea* accessions. Due to a late freeze, seed production on *Salix* accessions failed.

A total of 42 accessions were transplanted to the field mostly focused on *Aronia, Monarda, Spiraea, Staphylea, Rhus,* and *Salix*. Nearly half of these accessions were of *Monarda* to be utilized for collecting observation data. One accession of interest is *Abies balsamea,* which will serve as a future seed orchard. This accession represents one of the few remaining populations of *Abies balsamea* germplasm collected from a native remnant in Iowa.

Availability and Backup:

Currently, approximately 70% of the medicinals, 70% of the herbaceous ornamentals, and 53% of the woody landscape accessions are available.

Currently, approximately 74% of the medicinals, 77% of the ornamentals, and 46% of the woody landscape accessions are backed up at the National Laboratory for Genetic Resources Preservation (NLGRP) in Ft. Collins, Colorado.

The horticulture crew continued management of pollination screen repair in 2020. The team utilizes a commercial sewing machine to repair torn seams and broken zippers. A total of circa 20 screens were repaired in 2020 compared to 75 screens in 2019.

Viability Testing:

A total of 206 seed viability assessments were made for the horticulture collections including increase (13%), maintenance (26%) and original (60%) inventories. Maintenance tests were executed on available *Phacelia* and *Echinacea* accessions.

As a follow up from a cooperator researching *Fraxinus* that reported no viability of accessions received, tetrazolium tests were executed on 22 accessions (4C storage) and all accessions were recorded as not viable. Additional tests are in queue to compare against the same samples that were split and stored in -18C.

Viability tests were executed on recently harvested *Dirca palustris* (NA 85118), a taxon new to the NPGS collection and also unknown as to its storage capabilities. In 2018, seeds of NA 85118 were split into three handling/storage treatments:

1. -18C storage
2. 4C storage
3. After ripened for 8 weeks at 15C then -18C storage.

The initial base-line viability test executed prior to storage was recorded as 82% viable (tetrazolium test). After three years in storage, viability (tetrazolium test) dropped to 28%, 44%, and 8% respectively for the three treatments. Corresponding viability tests to achieve germination resulted in similar results (% norms) including 9%, 61%, and 3% respectively. However, germinated seedlings transplanted to small containers for greenhouse establishment resulted in very distorted seedlings. The establishment of seedlings based on the three treatments also had contrasting results. The percent establishment for each of the three treatments were 77%, 11%, and 0%, respectively. *Dirca palustris* should be considered short-lived in storage were delayed timing in storage results in significant loss in viability. Despite the 4C treatment providing the best results in both viability and TZ tests after three years in storage, the percent establishment of seedlings in the greenhouse was extremely low (11%) compared to the -18C treatment (77%).

Distribution:

Distribution figures for the horticulture collections are summarized in Table 2 and 3, below, and Appendix Table 3. For the combined horticulture program, we distributed 117 external orders to 96 requestors totaling 577 items from 434 accessions. We cancelled 529 orders from 469 requestors representing 3,233 items. Most of the orders were cancelled because they were requested for home gardening or other non-research use and/or commercial sources could meet the needs of the request. In addition to the 117 distribution orders, 21 orders from 13 requestors totaling 89 items from 26 accessions were for herbarium specimens sampled at NCRPIS or in nature. Orders in 2020 were requested for a variety of uses including breeding, additions to botanical gardens/arboretums, disease screening, seed testing for the Association of Official Seed Analyst exam, anthropological research, and restoration projects requiring known provenanced germplasm. An order for 47 accessions of *Cornus* spp. were distributed to High Point University in North Carolina to execute genetic analysis for taxonomic studies.

Table 2. Taxa most distributed from the NC7 horticulture program in 2020

Taxa	Most distributed (greatest to least)
Medicinals	*Echinacea*
	Monarda
	Agastache
	Calendula
	Hyoscyamos
Ornamentals	*Phacelia*
	Potentilla
	Thalictrum
	Drymocallis
	Alcea
Woody landscape	*Cornus*
	Salix
	Ulmus
	Sorbaria
	Fraxinus

Table 3. External domestic and foreign germplasm distributions for the NCRPIS horticulture program 2016 through 2020

Crop	Year	No. of Orders	No. of Recipients	No. of Items Distributed	No. of Accs Distributed
Medicinals	2016	36	33	99	99
	2017	53	44	387	233
	2018	44	36	218	169
	2019	53	47	404	293
	2020	44	42	267	196
	Average	46	40	275	198
Ornamentals	2016	33	30	72	61
	2017	27	26	174	160
	2018	46	40	117	93
	2019	22	21	63	55
	2020	30	28	108	100
	Average	32	29	107	94
Woody Landscape	2016	97	69	302	168
	2017	71	56	367	146
	2018	82	68	327	164
	2019	72	58	206	154
	2020	59	48	202	138
	Average	76	60	281	154

Characterization/taxonomy:
During 2020, two horticulture accessions *Salix* (1) and *Monarda* (1), were renamed based on a publication and morphological characteristics, respectively. No PI numbers were assigned. Communication with taxonomist Melanie Schori (USDA-ARS),

resulted in the addition of three new taxa to GRIN-Global database including *Agastache micrantha* (Ames 35595), *Blephilia woffordii* (Ames 35551), and *Salix* x *conifera* (Ames 35549).

Evaluation:
A common garden study/evaluation plot of select *Gymnocladus dioicus* accessions was established in 2017. This evaluation plot includes 52 wild collected accessions from across the species native range with typically 3 mother trees from each accession, replicated 5 times totaling 720 trees. The main goal is to identify superior accessions of *G. dioicus* germplasm. *G. dioicus* has recently become one of the more popular, widely planted, urban street trees.

We continue to capture observation data on nine *Betula nigra* accessions (145 trees), a common garden study hoping to identify elite lines for the Midwest. Data captured to date include chlorophyll concentration, caliper, and tree height.

A common garden study/evaluation plot of select *Hydrangea quercifolia* accessions (150 specimens) was established in 2020. This evaluation plot includes 15 wild collected accessions from across the species native range represented as 10 specimens per accession, planted in a completely randomized design. The main goal is to identify superior accessions of *H. quercifolia* including fall color, growth habit, floral display, and cold hardiness.

A total of 1,605 records were attached in GRIN as either images (652) or as documents (953) including publications, collection trip reports, viability cards, permits, field maps, passport data, and USDA NRCS Release documents. A total of 43 records were created for NC7 Trials Plants Descriptions (historical distributions) that readily provide the plant description documents on GRIN-Global public webpage.

A total of 22 observations were captured including flowering dates, capitulum diameters, fruit diameters, and fruit soluble solid contents. Additional data for twelve traits was captured on twenty-two *Monarda* accessions and is pending addition to GRIN-Global.

Enhancement:
A second generation grow out of *Quercus prinoides* (Ames 23752), established in 2016, totaling approximately 150 seedlings continues to be maintained. Seedlings were selected for mildew resistance and superior growth habit.

Coordination of the NC-7 Regional Ornamental Trials:
In 2020, the horticulture project did not distribute plants for regional trials. Select accessions of *Magnolia acuminata* (1), *Betula lenta* (2), and *Populus grandidentata* (1) are currently being grown for future distribution.

Posters, Presentations, and Seminars:
In 2020, Jeff Carstens hosted a tour of the NCRPIS to the Iowa State University Seed Science Center Seed Analyst Short Course class (10 students). All other activities involving conferences, tours, etc. were cancelled due to COVID-19 restrictions.

Conclusions:
The 2020 growing season was generally productive in terms of overall regeneration of the horticulture collections. Progress continued in the acquisition and curation of *Monarda* germplasm. Future acquisitions will switch to sampling of western *Fraxinus* species, *Monarda* spp., *Agastache* spp., and collaboration with Kevin Conrad to sample *Cladrastis kentukea.*

Plans for 2021:
For 2021, we will attempt to obtain seed increases from 40 horticulture accessions. Significant time will likely be spent reviewing plant inventory and removal of successfully increased accessions. Several accessions could be assigned PI numbers and paperwork to complete inactivation.

E. Maize Curation (M. Millard, V. Bernau, B. North, D. Zimmerman)

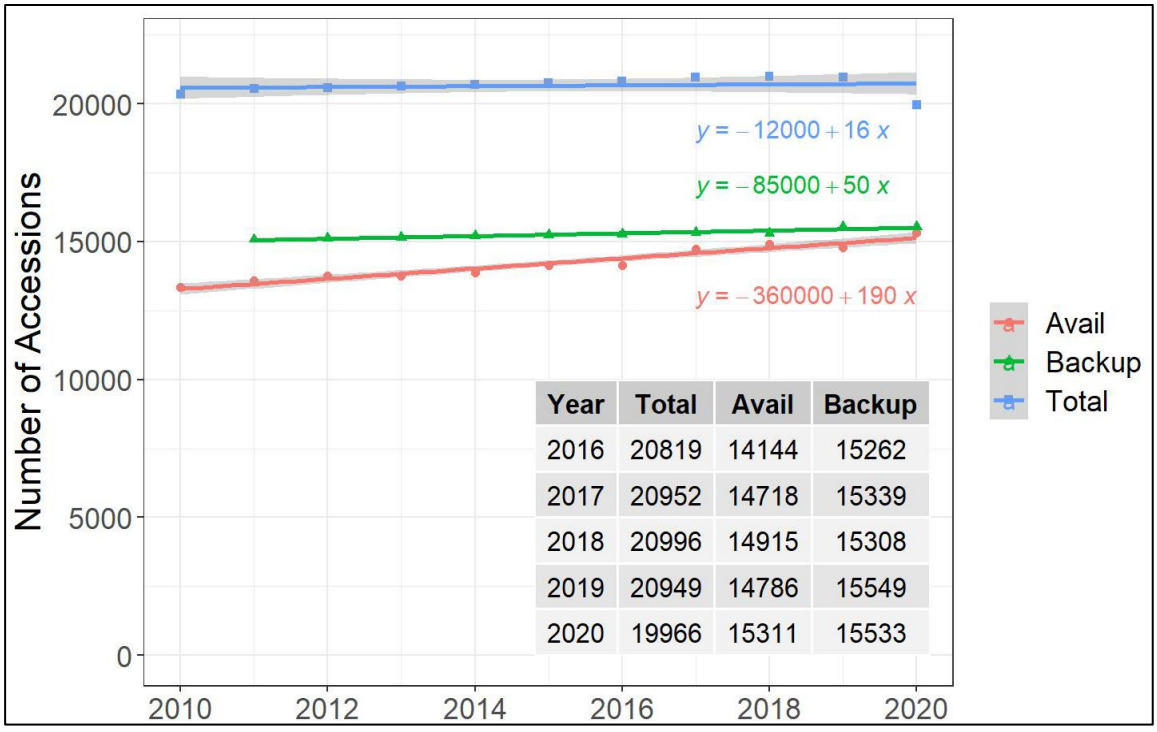
Project Management:
Curators Mr. Mark Millard and Dr. Vivian Bernau are assisted by full time ISU Agronomy Department staff, David Zimmerman (Agricultural Specialist II) and full time USDA-ARS staff. Brady North (USDA-ARS technician) resigned in August 2020 for a new opportunity working with industry. Brady worked at the station for 2.5 years (2012-2014) as an Agricultural Specialist (ISU) and six years as a Biological Science Technician (2015-2020). Brady was a master of ear description and will be missed. The position was advertised in November, and our new Agricultural Science Research Technician, Samantha Armintrout, will start in April 2021.

Acquisitions:
In 2020, 179 new accessions were acquired. These included improved popcorn accessions developed by Ken Zeigler (Iowa State), 30 BGEM double haploid (DH) inbred lines, seven GEM lines, and 93 PVPs expiring in 2020/2021 which were transferred from the NLGRP. The PVPs and BGEMs were increased in Ames in 2020. Seed of the Southern US landrace "Looney Corn" was acquired from Jeff Swann (White County, Tennessee) and Michael Washburn (Blackberry Farm; Walland, Tennessee) with help from David Shields (University of South Carolina). Two PVP accessions from the Republic of South Korean were also transferred to NCRPIS for increase in our quarantine greenhouse.

Tropical maize accessions (1,200) were transferred from the NLGRP in October 2019 for distribution and management in Ames. The material transferred included about 500 accessions with previous unsuccessful regeneration attempts, and 700+ new accessions. Accessions with distributable amounts are being prioritized for processing and will be assigned PI numbers if viability is good. Critical backup samples of these accessions are returned to NLGRP after processing, based on seed inventory. As of December 2020, 346 accessions have been made available and critical backup samples of 411 accessions have been sent back to NLGRP.

Maintenance:
There were 19,913 accessions of *Zea* in the active collection at the NCRPIS as of December 31, 2020. The maize curators maintain an additional 53 accessions from the *Coix* and *Tripsacum* genera (Figure 1).

There were 15,303 available *Zea* accessions held at the end of 2020 (76.85% of the total). This represents a significant increase in availability, despite fewer student employees and reduced regeneration activities due to COVID-19. Low viability dictated making 53 accessions unavailable. A total of 769 new distribution lots were made available in 2020. Progress has not and will not be possible without the in-kind regeneration assistance of private companies and the GEM programs in North Carolina and Iowa.



Year	Total	Avail	Backup
2016	20819	14144	15262
2017	20952	14718	15339
2018	20996	14915	15308
2019	20949	14786	15549
2020	19966	15311	15533

Figure 1. Maize collection holdings, availability, and backup status. December 31, 2020.

Accession Backups:
A significant 868 accessions were backed up at the NLGRP in Fort Collins in 2020. This compares with 156 in 2019 and 202 in 2018. However, the number of accessions in the collection with backup samples statistically stay steady at 15,533 accessions (78%) because most of the backups that have been sent to NLGRP have not been processed and added to their inventory. Currently, NLGRP needs are not the highest priority for regeneration, but are considered. Since there is a large backlog of accessions needing regeneration, viability of the Ames inventory and availability are the more important priority setting factors. At storage of a new increase, NLGRP holdings are reviewed for each accession and seed is sent to NLGRP if their backup is considered substandard. The increase of backup samples sent in 2020 reflects an increased effort to assign PI numbers to accessions long held as Ames numbers.

Regenerations:
A total of 316 regenerations were attempted. As of December 2020, 233 harvests had been made during the calendar year.

The size of our Ames nursery was significantly smaller in 2020 than in most years due to COVID-19 restrictions. The hiring of temporary workers in Ames during the summer pollination period continues to be difficult, but we were lucky to have a crew of mostly returning pollinators who worked enthusiastically and efficiently through the summer, coping with pandemic safety protocols. Regenerations were limited to PVPs expiring in 2021, a handful of PVPs that were drowned out in the 2019 nursery, BGEM releases, and a few high priority inbred lines.

Stewart's wilt was not observed in any increase plots in 2020, as in every year since 2010. ELISA testing is still necessary on Ames increase lots to meet phytosanitary requirements for international distributions because the state cannot be declared Stewart's wilt free.

Ames greenhouse increases included ten inbred accessions planted in February 2020. One population of *Zea luxurians* (teosinte) was planted in June 2020 for a winter harvest. The pots were treated with Paclobutrazol (Bonzi®, Syngenta Crop Protection, LLC; Greensboro, North Carolina) during the growing season to control height and to encourage tillering. In early September they were moved to the greenhouse and placed under LED lights set to short day photoperiods. The population flowered well, and harvest ran from November 2020 through January 2021. More than 75,000 viable cupules were harvested.

Quarantine maize was grown in a NCRPIS winter greenhouse for the third time during the winter of 2019-2020. Repairs, including the installation of new benches, began in the fall of 2019 delaying planting five inbred lines from Thailand by a month (until December) for the 2019-20 cycle. These inbred lines have had poor tassel emergence and pollen shed. Technician Brady North attempted several different modifications to the greenhouse with limited improvement to plant production.

For the fourth quarantine cycle (winter 2020-2021), with the added uncertainty of COVID-19 precautions, we decided to try different germplasm in the space. Two accessions received from the Republic of South Korea for PVP were sown in November 2020. We continued to have struggles using this greenhouse space. The thermostat malfunctioned for several days in January 2021 following an ice storm. This caused the room temperature to reach 103F during peak pollination of one of the accessions, which may have affected pollen viability and therefore pollination success.

A tropical nursery consisting of 62 mid-altitude to lowland accessions was sent to Semillas Moreno Retis (SMR) in Nayarit, Mexico in the fall of 2019 and harvested in early 2020. Seed was received on the ear at the end of March 2020. Processing was completed in November 2020. Our target population of 100+ ears was reached for 13 accessions. More than 60 ears were received for 32 accessions. All 62 accessions have been made available for distribution.

We shipped an additional 121 accessions for a third increase by SMR in September 2020. Seed was received on the ear in March 2021. Based on issues exporting seed grown outside of the United States to Mexico in 2019, we only sent material of domestic origin. We have made progress working this issue and will attempt to resume re-exports of seeds grown in Mexico for the 2021-2022 winter nursery. To review, this nursery was set up to assist in regenerating accessions that would grow best in the tropics. We have seed of several thousand accessions that were grown in Peru, Mexico, and Colombia in the 1986-1995.

St. Croix grew 20 accessions (10 populations, 10 inbred lines) in 2020. Seed was received on the ear in September 2020, and processing was completed in December 2020. The target population of 100+ ears to capture diversity was achieved for all the populations. At present, APHIS will not issue a permit to grow quarantine maize in the field in St. Croix, only in a greenhouse. Dr. Goenaga is working with others in ARS to try to remedy this situation.

CIMMYT (International Maize and Wheat Improvement Center) grew 25 Peruvian highland accessions in Toluca, Mexico under USDA-ARS contract in 2020. This is the second nursery contracted with CIMMYT. Shipping of the harvested nursery has been delayed due to COVID-19 working restrictions at CIMMYT research stations.

Viability Testing:
There were 3,967 accessions tested for viability in 2020 (20% of the collection). This is more than twice the number of accessions tested in 2019. A less resource-consuming viability testing plan was implemented in 2018 using two replications of 10 seeds followed by standard testing (four replications of 50 seeds) for accessions with low viability. This testing plan continues to be used and has provided better information for curators as they choose planting quantities for the increase nurseries.

Most accessions are tested on a 10-year plan. The collection has current viability test data (<10 years old) on 10,453 accessions (52.3% of the collection) (Table 1). However, 5,537 available distribution lots (36.1% of available accessions) have viability tests older than 10 years, and 2,602 available distribution lots (17% of available accessions) have tests more than 15 years old. The current distribution lots of more than 25% of the available accessions (and 29% of the whole collection) were grown in 1990 or earlier; we expect to see more accessions being made unavailable with further maintenance testing (Figure 2).

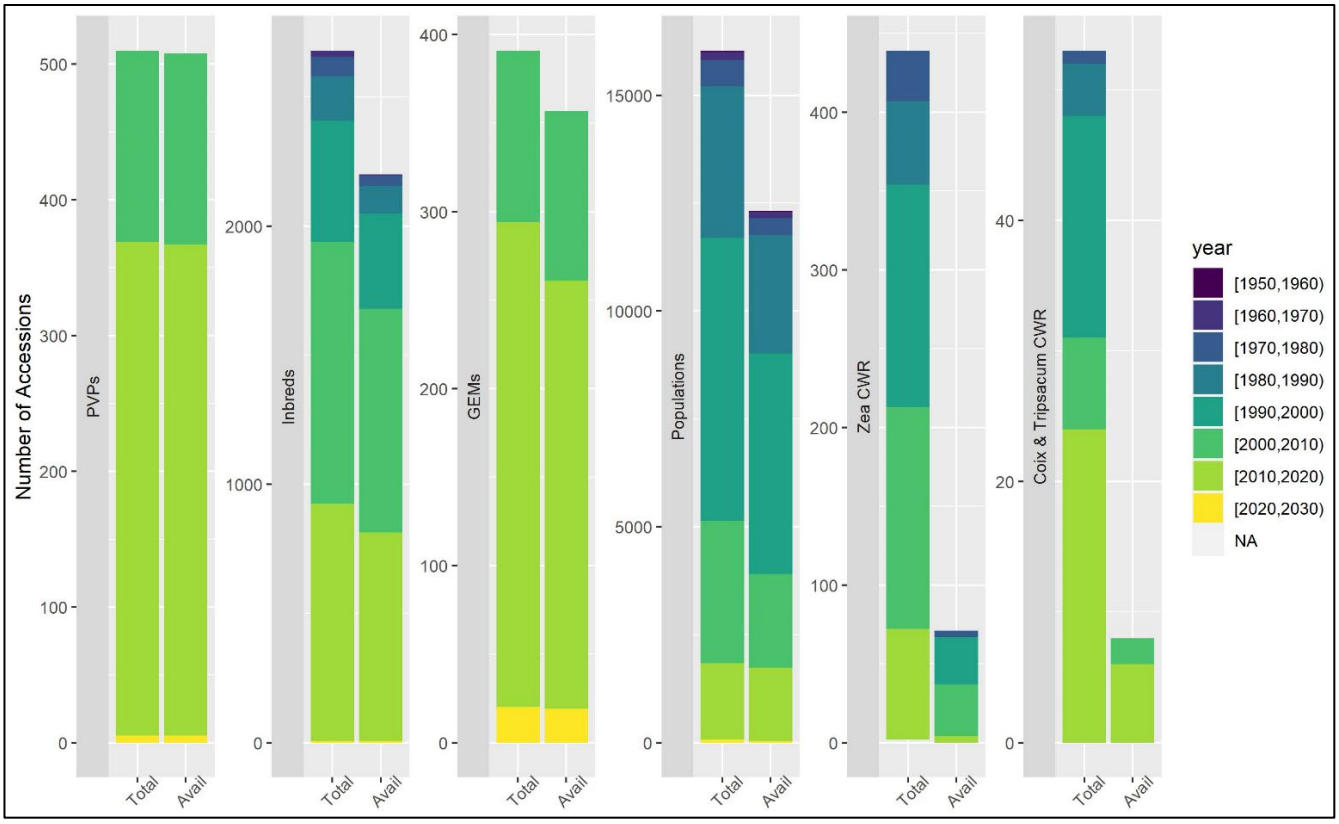


Figure 2. Comparison total to available accessions according to accession type. Each bar is colored according to the approximate age of the current or last distribution lots.

Characterization and Evaluation

A total of 1,730 images on 1,028 accessions were loaded to GRIN in 2020. This increased the maize images on GRIN to 18,490 images on 8,357 accessions.

There were 36,697 data points on 6,200 accessions loaded to GRIN in 2020. This compares with 22,067 data points on 1,504 accessions loaded to GRIN in 2019 and 16,173 data points on 1,241 accessions loaded into GRIN in 2018. We imaged 1701 accessions in 2020 compared to 861 accessions in 2019, and 565 accessions in 2018.

Germplasm Management

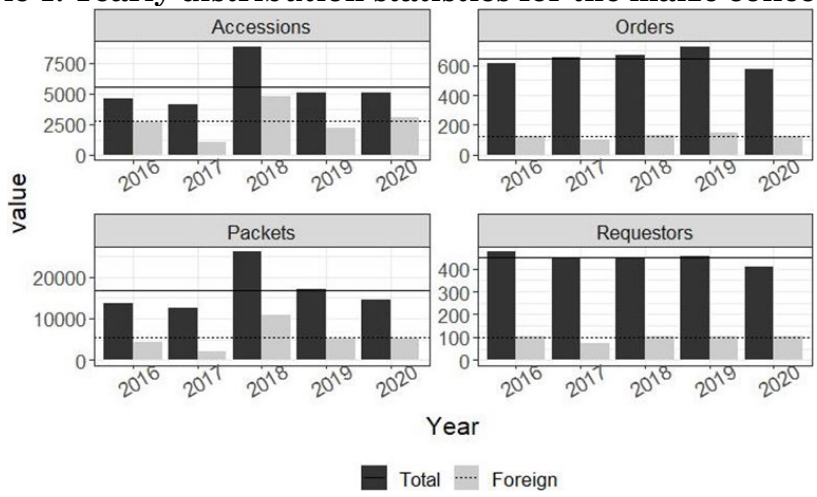
A total of 1,530 accessions were inactivated in 2020. Inactivation of an accession occurs when it has been determined the accession cannot or should not be maintained as part of the active inventory of the North Central Regional Plant Introduction Station (NCRPIS). Following a vote at the Maize CGC meeting in December 2019, 1,444 accessions donated as the PCM/WCG collection were inactivated in January 2020. The accessions represent maize and wild relatives collected across Latin America by PCM, WCG, and their collaborators between 1930 and 1980. Before inactivation, V. Bernau updated the passport information associated with the accessions according to a hand-written catalog that accompanied the collection. As provided in the catalog, collection and donor source information was uploaded for all accessions, and local and collector names were added to the accession records. Though they are no longer part of the active collection, these accessions will continue to be stored at -18°C.

New PI numbers were assigned in to 376 accessions in 2020. Preparations for PI number assignment include proofing and updating of all passport data, determining that there are no duplicate accessions, verifying accession viability, and determining whether any Material Transfer Agreement (MTA) or Intellectual Property Rights (IPR) restrictions apply to the material.

Distribution:
Overall, order items filled from the maize collection items decreased by 17% in 2020. The number of items filled of maize populations, wild *Zea* species, *Coix* and *Tripsacum* increased relative to 2019, while the number of items filled for GEM lines, inbreds, and expired PVPs decreased. This likely reflects the impact of COVID-19 on breeding nurseries relative to basic research. Almost all orders are now entered by requestors in GRIN-Global. Expired PVP-lines continue to be a major maize distribution category followed by NAM inbred parents, the Goodman-Buckler inbred diversity set, and all other inbred lines. Targeted requests for fewer accessions continue to comprise the bulk of the orders. Handling this number of packets would be very difficult without GRIN-Global and the hard work of Ms. Stacey Estrada, Ms. Lisa Burke and their teams in order processing and seed storage.

Plans for 2021:
In 2021, as in recent years, attending to regenerations and regeneration processing take precedence. Without viable seed, distribution and resulting research cannot be done. To better focus these regenerations, we look forward to updated viability status for maize populations from the germination team.

Table 1. Yearly distribution statistics for the maize collection



Year	Total Packets	Foreign Packets	Total Accessions	Foreign Accessions	Total Orders	Foreign Orders	Total Requestors	Foreign Requestors
2016	13541	4252	4572	2707	611	121	473	106
2017	12541	2095	4137	1042	655	99	451	73
2018	25993	10846	8833	4834	671	131	456	107
2019	17139	5025	5065	2217	722	147	456	104
2020	14516	5148	5112	3062	572	123	406	105

When the initial batch of 1,200 tropical maize inventories transferred from NLGRP has been processed and stored, another set of 500-1000 inventories will be requested. Transfer of seed lots with >2500 seeds are being prioritized. Transferring the 11,284 packets is expected to take about 10 years. More than 5,000 accessions are expected to require regeneration.

Our tropical regeneration nursery (125 accessions) in Puerto Vallarta, Mexico was received in March 2021 and will be processed through the spring and summer months. An additional tropical regeneration nursery in Puerto Vallarta is planned for 2021-2022.

We look forward to the return of our 2020 highland nursery grown on contract with CIMMYT. These 25 accessions were planted in Toluca, Mexico at the end of March 2020 (received June 2021).

NSL and Ames numbered accessions will continue to be reviewed, and PI numbers assigned. Over 965 Ames-numbered and NSL-numbered accessions need to be reviewed and considered for permanent PI numbers in 2021.

We will continue acquiring germplasm from public collections. We received a portion of Dr. Don White's inbred collection from Dr. Tiffany Jamann at the University of Illinois in January 2020. Six inbred lines developed by Dr. Jim Brewbaker (University of Hawaii) were donated by Dr. Mikey Kantar and Jay Bost in March 2021.

We will augment the collection of 18,490 images currently on GRIN-Global with images of additional accessions in 2020. Efforts to digitize and edit images for upload will also continue in 2021.

F. Oilseed Crops (L. Marek, G. Welke, J. Schwartz)

Project Management:
Curator Dr. Laura Marek was assisted by full time Agronomy Department staff, Grace Welke, ISU Agronomy Research Scientist III, and by Jeff Schwartz, USDA-ARS Agricultural Research Technician. John Reinhardt, ISU Farm Equipment Operator works with the NCRPIS Oilseed Project December through March. Due to NC7 Hatch Project funding constraints, Mr. Reinhardt worked very limited hours during November – March, 2019-2020. In December 2020 budget adjustments allowed him to rejoin to Oilseeds full time for his four-month detail at the NCRPIS. The Oilseeds Project is also supported by a team of hourly student workers. Due to pandemic effects on operations, oilseeds regenerations were decreased 25-30% during 2020 and regenerations were once again focused on fewer very straightforward taxa. Other operations such as seed processing and storage are also running behind a typical year both due to pandemic constraints on operations, Mr. Reinhardt's reduced hours 2019-2020, and reduced availability of student labor.

Acquisitions:
The oilseed project received 18 new accessions in 2020, which included seven *Helianthus* and two miscellaneous asters. In addition, one *H. gracilentus* (perennial

species) population located in the hills above San Luis Obispo, CA and collected by the curator in two separate explorations without recovering viable seeds, was sampled much earlier in the season by Dr. Thomas Gulya, retired USDA plant pathologist living in northern California. Dr. Gulya's exploration returned 5000 seeds of acceptable viability. Dr. Marek arranged with the NPGS Plant Exchange Office to support Dr. Gulya's collection travel.

Helianthus:
In addition to the *H. gracilentus* re-collection mentioned above, Dr. Gulya collected an additional four *H. gracilentus* sunflower samples from two populations of *H. exilis* (annual species), one of which, collected south of San Jose, CA, represents the most southern population of this taxa sampled in the NPGS. Dr. Chase Mason, University of Central Florida, visited Oscar Scherer State Park northeast of Venice, FL and collected seeds from a population of *H. debilis* ssp *vestitus* under a renewal of Dr. Marek's 2015 permit. During the previous trip a population large enough to sample was not located.

Miscellaneous Asters:
Dr. Chase Mason provided seeds from a population of *Encelia californica* collected by student Mari Irving in CA as well as seeds from a late fall 2019 collection in FL of *Phoebanthus grandiflorus*, of interest because it is the closest sister species to *Helianthus*.

Maintenance:
General statistics about availability and management of the collections are presented in Appendix Tables 1 and 2. Two unexpected events occurred during 2020 which effected oilseed regenerations. First, necessary protocols put in place to provide for safe interactions during the covid 19 pandemic slowed all activity and decreased the availability of student labor. Secondly, the farm experienced a derecho windstorm (inland hurricane force winds) on August 10th which among other effects, damaged and destroyed oilseed cages as noted below. Selected details for oilseed accessions increased during 2020 are noted below. Mr. Reinhardt's return to the Oilseeds Project in December for a full time four-month stint will allow the team to get caught up on seed processing.

Helianthus, Ames regenerations:
Cultivated *H. annuus* accessions are 92% available for distribution. We manage regenerations to ensure that core collection accessions and other accession subsets of interest to specific stakeholder groups are available.

In 2020, 81 cultivated *H. annuus* accessions were regenerated in the field including ten UGA-SAM1 association mapping population lines and nine accessions recently received from the USDA's Fargo sunflower breeding program. Five of the plots were lost to the derecho windstorm on August 10th and those accessions will be regrown in 2021. Seeds were harvested from all plots except those lost to the derecho.

Wild annual *Helianthus* accessions are 95% available and wild perennial accessions are 85% available. Twenty-seven wild annual sunflower regenerations were started

in Ames in 2020. Nine of which were lost to the derecho windstorm and will be re-planted in 2021. Seeds harvested from all other plots are being processed.

Figure 2. Derecho destruction of wild annual sunflower regeneration cages.

Typically, several oilseed accessions requiring long seasons or short days to flower are increased in a NCRPIS greenhouse during the winter. In winter 2019-2020, we attempted one cultivated sunflower. The cultivated sunflower was a genetic breeding stock that produced little pollen and no viable seed. No sunflowers were started in the greenhouse for 2020-2021; all available space was used for winter flowering type *Brassica* regenerations. One accession of the wild annual species *H. debilis* ssp. *debilis* developed for ornamental uses and dune restoration is maintained clonally in the greenhouse and distributed as vegetative clones.

Miscellaneous asters, Ames regenerations:
The miscellaneous asters are 35% available. Two *Centrapalus* accessions were attempted in the 2019-2020 winter greenhouse regeneration; one did not germinate, and one grew well (although only a few plants) and seeds were harvested.

Helianthus and Miscellaneous asters, Parlier alternate grow-out site regenerations:
We continue to partner with the National Arid Lands Plant Genetic Resources Unit (NALPGRU), Parlier, CA to regenerate wild taxa requiring a longer growing season than is reliably obtained in Ames as well as those species that do not grow well in mid-western humidity and heavy soils. The Parlier location uses cages purchased by the NCRPIS and can grow up to 40 NCRPIS oilseed accessions per year. We germinate seeds in Ames and ship live seedlings to Parlier in late March and early April. Parlier staff transplant the seedlings and manage plant growth. Following our Ames protocol,

plots are caged before flowering, pollinator insects are introduced (honeybee services supported with Ames resources), and seed heads are harvested as they mature. Harvested material is shipped to Ames for threshing and processing.

In 2020, we were fortunate to be able to continue to send seedlings to California and the location there was able to handle the regenerations for the most part as they do in a typical year. We shipped seedlings of 33 wild sunflower accessions and two miscellaneous asters to Parlier. Seeds were returned for all 2020 accessions except one of the asters, *Encelia californica* (new acquisition mentioned earlier in the report), which was flowering at the end of 2020 but did not have mature seed; therefore, it was maintained to harvest in 2021.

The Parlier staff record basic field observations (transplant, flowering, and harvest dates and some image capture) but they do not have the resources to record standard descriptor data such as ray and disc flower color, plant height, and branching characteristics nor to take all images. Phenotypic information is a valuable component associated with each accession and it is important to capture the observation data. Typically, Grace Welke and I travel to Parlier in September and record those data; however, in 2020 travel was not permitted due to the pandemic and the data were not captured. The Parlier curator imaged most plots so that species identity could be confirmed.

We have an excellent partnership with the NALPGRU staff, ensuring successful regenerations of many taxa. We are most grateful for the dedicated efforts of Dr. Claire Heinitz, Curator, and Mr. Jerry Serimian, Agricultural Research technician, and their staff. Mr. Serimian, who had been with Parlier since the site was established in 1996, retired in September 2020 and the location is in process of refilling his position.

Brassicaceae regenerations:
Brassicaceae accessions are 86% available. We continue to prioritize regenerations of the low viability *Brassica* accessions whose status was brought to our attention during maintenance viability testing started in 2016 and completed in 2020 (some lots fell by as much as 80% in the 6 or 10 year interval since prior testing), with 460 lots determined at 50% or less viability over the testing interval and an additional 388 falling between 50 and 70%. We have been able to regenerate 75 of the low viability accessions per year since 2018, starting with the lowest viability accessions. The viability testing data were received too late in 2016 to begin winter flowering type regenerations and 12 low viability spring flowering types were grown in 2017. We request seed from the Ft Collins backup lot for accessions with very low viability, roughly 100 accessions to date.

Most of the accessions with low germination distribution lots are of *B. napus* (83%), and most of those are of winter flowering type, requiring a vernalization period to induce flowering. In past trials, most winter flowering type accessions do not survive the winter in the field in Ames; therefore, we start winter flowering types in the greenhouse and induce flowering using our vernalization space. In December 2019, we started 75 *Brassica* accessions, seeds of one did not germinate, and 74 accessions were kept in the greenhouse until mid-February 2020 when they were moved to the

vernalization rooms. In addition, five spring flowering type *Brassica* accessions were started in germination boxes in early April and all seedlings were transplanted to the field. All plots were harvested, and seed processing is underway. Eighty 'probable' winter flowering type Brassica accessions were started in late November 2020 for growth, vernalization and spring 2021 transplanting to the field.

Figure 3: Winter flowering type *Brassica*. A) Accessions on racks outside the vernalization space awaiting transport to the field. B) One accession in the field flowering nicely four weeks later.

NCRPIS GH-2 is managed in the winter to provide conditions that approximate a Mediterranean climate allowing us to regenerate Brassicaceae accessions native to that region, and to grow other Brassicaceae taxa which flower very early in the growing season in Ames. In fall 2019, we started 14 accessions in GH-2, one each of *Camelina sativa* and *Camelina rumelica* ssp *transcaspica*, seven *Camelina* spp accessions, and one each of *Sinapis arvensis* ssp *arvensis*, *Erysimum menziesii*, *Biscutella laevigata*, *Crambe kralikii* and *Hesperis matronalis*. The seven *Camelina ssp* accessions were among a group of nine donated without specific epithet from a 2014 collecting exploration in Armenia. Along with two accessions grown in 2019-2020, we have been able to verify taxonomic identification of all nine accessions. Seeds were harvested from all 14 accessions. In fall 2020, we started 20 accessions, 12 of which did not germinate and will be inactivated (10 *Alliaria petiolata* and two *Matthiola incana*). The remaining eight accessions all have plants growing for 2021 harvest: two accessions of *Camelina microcarpa* and one each of *Camelina laxa*, *Erysimum gomez-campoi*, *Lepidium fremontii*, *Matthiola ovatifolia*, *Sinapis alba* and *Thlaspi arvense*.

Linum regenerations:
Cultivated flax accessions are 99% available; wild flax accessions are 84% available. Ninety-seven percent (2778 accessions) of the large cultivated flax collection was transferred to Ames in 1998/1999 and these accessions were of uniform seed age. The NCRPIS viability lab determined that seed viability had started to decline for some distribution lots and increased their maintenance germination testing for this crop completing the current viability testing cycle in 2019. Based on the resulting data, we are now regenerating 45 accessions of cultivated flax every year, with priority given to accessions with lowest viability with the long-term goal that all distribution lots have 80% or higher viability. In 2020 the planned regeneration of cultivated flax were postponed due to decreased fieldwork capacity because of pandemic restrictions. We did attempt seven accessions of wild flax, one annual and six perennials; one perennial accession did not germinate. Due to covid related delays, the plants were not put into the field until June, late for wild flax, and only three of the accessions flowered; seeds were harvested from only one. Plants from one accession with few remaining seed were transplanted to pots and maintained in the greenhouse. The other perennial accessions were left to overwinter in the field. The one annual species accession will be re-planted in 2021.

Cuphea regenerations:
We had planned to re-start *Cuphea* field regenerations in 2020; this work was postponed, also due to decreased fieldwork capacity. Seeds are available for 94% of the accessions of seven species (*Cuphea calophylla, C. carthegenensis, C. lanceolata, C. lutea, C. tolucana, C. viscosissima, C. wrightii)* and for the *Cuphea* hybrid accessions that were part of agronomic development efforts of the (now inactive) National *Cuphea* Consortium. Thirteen accessions of *Cuphea* are maintained as clones in the greenhouse and distributed as vegetative cuttings. Overall, the *Cuphea* collection is 80% available.

Euphorbia regenerations:
The *Euphorbia* collection (210 accessions) is 49% available. The taxon of interest for seed oil production within this genus is *E. lagascae* and its accessions are 93% available. No *Euphorbia lagascae* accessions were attempted in 2020 also due to decreased fieldwork. Six *Euphorbia* accessions are maintained as clones in the greenhouse and distributed as vegetative cuttings.

Distributions:
212 unique orders containing 7368 oilseed packets were shipped in 2020. General statistics about oilseed distributions are presented in Appendix Table 3. A summary of the distributions separated by international and domestic distributions is presented in Table 1 below. Although the NCRPIS was able to continue to fill and ship most domestic orders during the pandemic, international shipments were halted for months and a backlog of inspections for issuance of phytosanitary certificates for international shipments still exists. There was an approximate decrease of 25% in oilseed orders shipped in 2020 compared with 2019 and close to a 50% decrease in the number of items distributed. The expectation is that some amount of the decrease in distributions was related to aspects of the pandemic.

Table 1: Summary: Oilseed Crops 2020 Distributions

Crop	shipped orders 2020	packets	international orders	international packets	international requestors	domestic orders	domestic packets	domestic requestors	total requestors
Brassicaceae	104	3802	15	1162	15	89	2642	70	84
Cuphea	3	57	1	53	1	2	4	2	3
Euphorbia	2	3	2	3	2	0	0	0	2
Helianthus	93	2975	27	1835	24	64	962	49	71
Linum	14	520	6	197	6	8	323	8	14
misc asters	7	15	2	3	2	5	12	5	7

Note: Because some orders contain items from more than one crop category, the total number of unique orders is less than any totals calculated from the table.

Helianthus:
A little less than half (47%) of the total *Helianthus* items distributed in 2020 were sent to seed companies or other commercial entities, 91% of which were sent to international destinations, reflecting current locations of most of the commercial sunflower breeding programs. Programs associated with public institutions, primarily universities, and national institutes received 53% of the distributions. Sunflower packets were sent to support breeding programs (45%; the category most seed companies identified as their research purpose), pathology research (18%), and abiotic stress research (13%). Seventy-four percent of the total distributed packets were of cultivated *H. annuus* accessions, 17% were wild annual sunflowers including wild *H. annuus* and 8% were wild perennial sunflowers.

Brassicaceae:
The genus *Brassica* accounted for almost 75% of the 2020 Brassicaceae distributions (2828 total packets, 1366 unique accessions). The Brassicaceae genus with the second largest number of packets distributed was *Sinapis*: 321 packets, ~8.5% of the total. The diversity present in the Brassicaceae collection (262 taxa in 21 genera) supports a very wide range of research purposes including genetic studies, details of which vary

widely, pathology research related to disease resistance, varietal development, bioremediation, and investigations of plant-produced defense compounds.

Linum:
Sixty five percent of the flax packets distributed in 2020 were wild flax accessions. Sixty-two percent of the distributions were sent to domestic requestors, including the largest single distribution to a research program focused on the domestication of perennial flax. In addition, wild flax accessions were sent to support taxonomic research and to a researcher generating pre-breeding lines in search of useful traits to improve cultivated flax. Cultivated flax accessions were requested to support breeding, pathology research and the development of a transformation process.

Cuphea:
Cuphea accessions were distributed in 2020 to two different breeding programs: one enhancing ornamental use and one working with seed oil composition.

Euphorbia:
Euphorbia accessions were distributed in 2020 for a breeding project and to a researcher studying weed competition in wheat.

Miscellaneous asters:
Miscellaneous aster accessions were distributed in 2020 for seed reference and identification collections.

Research Activities:
General statistics about observations and images entered into GRIN for the collections are presented in Appendix Table 4.

Helianthus:
NSF project: In 2020, we received funding to complete an evaluation of SAM accessions determining the rate of autonomous self-pollination in cultivated sunflower. Dr. Jessica Barb began the work in 2013, continued it in 2015 and 2016, identifying a subset of lines with clear difference in seed set depending on the presence/absence of pollinators. This work became part of a larger examination of pollination in sunflower funded by NSF and led by Dr. Stacey Harmer at UC Davis. It was preferred that the autonomic self-pollination evaluation be completed in the environment of the original observations; hence, the funding for Ames. Our efforts were affected by an outbreak of cutworms when the seeds were germinating requiring extra field work and some replanting, and by the derecho windstorm on August 10th. Many of the accessions were fully flowering on August 10th and two plots were lost because the cages were extensively compromised. Fortunately, those two cages were replications of the same accession, so only one accession was lost. Other cages were damaged but not to the point of exposing plants and losing/gaining bees and could be repaired/saved. Seeds were harvested and processing is underway.

Figure 4: NSF plots with waxed paper cup barriers to help control cutworm activity.

The Crop Trust: Loren Rieseberg's lab at the University of British Columbia developed the GB_UBC pre-breeding lines with support from The Global Crop Diversity Trust. The Crop Trust provided funding for an international evaluation effort of these lines, "Evaluation of Sunflower Pre-Bred Lines for Stress Resistance and Associated Trade-off with Yield", managed by the University of British Columbia group with partners in Chile, Argentina, Africa, India, Israel and Ames. We contribute to the partnership by providing seeds for the international locations and recording descriptor data during the regeneration process. Funding was received in 2017 ($25,000) for two years with a no-cost extension ensuring all funds are spent by June 30, 2020 to ensure seed availability.

Brassicaceae:

Brassica rapa flowering type evaluation: We are in the process of evaluating the 675 accession NCRPIS *B. rapa* collection for flowering type (winter or spring). Knowing whether vernalization is required to obtain flowering (winter type), allows more efficient management of regeneration efforts. Spring flowering types can be direct seeded in the field in the spring, a much less resource intensive process than growing seedlings in the greenhouse, transferring to and maintaining plants in a vernalization location, followed by transplanting to the field. In 2019-2020, we evaluated 100

accessions of which 75% were spring type (flowered fully without vernalization). In early December 2020 we started another set of 100 accessions. Observation priority was determined based on viability data; lowest viability accessions were evaluated first so that those accessions could be incorporated into regeneration priorities. Roughly 350 accessions remain to be scored. Scoring is final for 291 accessions and of those, 75% are spring type, whereas the B. napus collection is about 20% spring type. About 50 accessions need to be re-tested.

Professional Activities:

Meetings and Presentations:

January: I participated in the National Sunflower Association's 42nd Annual Research Forum in Fargo, ND, and led the satellite Sunflower CGC meeting. Anna Testen, NCRPIS plant pathologist, traveled along to Fargo to be introduced to the sunflower community and meet with the USDA and NDSU plant pathologists.

June: I participated in the PGOC virtual meeting on the 23rd and 24th, as well as the NCRPIS RTAC virtual meeting, mornings of the 29th and the 30th.

September: September 8th and 9th, I attended the 32nd annual AAIC meeting (virtual).

October: On October 1st, I attended PGR Canada's virtual annual meeting celebrating their 150th Anniversary.

November: I attended the virtual Tri-Societies meeting the 9th through the 13th, participating in all Crop Science C-08 (Plant Genetic Resources) sessions and additional sessions of interest.

December: I attended the virtual New Crops CGC meeting on the 2nd and gave an abbreviated presentation of the Brassicaceae, *Centrapalus*, *Cuphe*a and Euphorbiaceae (BCCE) collections report.

Training:

Throughout the year, I completed safety trainings as required including Epipen and Fire Extinguisher use and assigned AgLearn modules.

Publications:

Terzic, S., Boniface, M-C., Marek, L., Alvarez, D., Baumann, K., Gavrilova, V., Joita-Pacureanu, M., Sujatha, M., Valkova, D., Velasco, L., Hulke, B., Jocic, S., Langlade, N., Munos, S., Rieseberg, L., Seiler, G., Vear, F. 2020. Gene banks for wild and cultivated sunflower genetic resources. Oilseeds and fats, Crops and Lipids (OCL). 27(9):1-14. https://doi.org/10.1051/ocl/2020004.

Byrne P., Marek L. 2020. Case study: Sunflower Domestication and Breeding. In: Volk, G.M., Byrne, P., editors. Crop Wild Relatives and their Use in Plant Breeding. Fort Collins, Colorado: Colorado State University Pressbooks. Available from https://colostate.pressbooks.pub/cropwildrelatives/chapter/case-study-sunflower-domestication-and-breeding/.

Active Grants:

Crop trust:

In 2017 the ISU Curator for the Oilseeds project received a $25,000 grant from the Global Crop Diversity Trust administered through the University of British Columbia to support regenerations of the Canadian developed GB_UBC sunflower pre-breeding lines received in 2016 and to provide partial travel support to attend the project's annual meetings at the Plant and Animal Genome conferences in San Diego, CA. The last of the funds were spent to support student workers in 2020.

NSF:

In 2020 I received $10,757 for a one season field evaluation finalizing work begun in 2013 and continued in 2015 and 2016 by Dr. Jessica Barb, then at ISU, investigating self-autonomous pollination in cultivated sunflower. The investigation became part of larger work managed by Dr. Stacey Harmer at UC Davis and funded by NSF which included funding for the ISU work to complete the evaluation cycle.

Collecting:

I arranged with Karen Williams Plant Exchange Office USDA-ARS to fund Tom Gulya to collect in CA summer 2020.

I served as PI for a domestic collecting grant managed by David Brenner which was expended during 2020 in the collection of Chenopodium species, crop wild relatives of quinoa.

Service Activities:

Tours:

There were no in person tours in 2020 due to the pandemic.

Interview:

Local radio station KHOI interview with Mary Richards Science Bytes host discussion about careers in science, genetic resources and sunflowers, broadcast on 6/23/2020.

Journal peer review:

I served as a peer reviewer for one submission to Gene and two papers for the Journal of Industrial Crops and Products.

CSSA Genetic Resources C08:

I served on the Frank Meyer Medal committee member.

Plant Germplasm Operating Committee (PGOC):

I serve as a member of the PGOC GIS and Geo-referencing Subcommittee and the Molecular Subcommittee. The GIS and Geo-referencing Subcommittee began meeting again in fall 2020 to clean up descriptor data in GRIN Global now that the database is fully functional.

G. Vegetables (K. Reitsma, L. Clark, C. Hopkins)

Collections curated by the Vegetable Project include *Cichorium* (NC7-chicory), *Cucumis sativus* (NC7-cucumis.cucs), *Cucumis melo* (NC7-cucumis.melo), *Cucumis* species (NC7-cucumis.wilds), *Cucurbita pepo* (NC7-cucurbita), *Daucus* (NC7-daucus), *Ocimum* (NC7-ocimum), and *Pastinaca* (NC7-parsnips). Statistics for accession numbers and availability for each site crop are found in the appendices in "Table 1: NCRPIS Accessions (Accs), Acquired, Available", but are also summarized specifically for the Vegetable Project in the table below.

Site Crop (Maintenance Policy)	Number Accs	Number Accs Acquired	Number Available	Percent Available	Percent Avail Last Year	PI Number Accs	Ames Number Accs	NSL Number Accs	Total Number Backed Up at NLGRP	Percent Backed Up at NLGRP	Accns Sent to Svalbard for YR	Total Backed Up at Svalbard
NC7-chicory	285	0	254	89	86	231	28	26	260	91	65	179
NC7-cucumis.cucs	1401	0	1334	95	95	1230	143	28	1335	95	113	1098
NC7-cucumis.melo	3228	0	1936	60	60	2906	283	35	2605	81	140	691
NC7-cucumis.wilds	318	0	207	65	65	245	73	0	210	66	25	76
NC7-cucurbita	980	0	725	74	75	885	90	5	828	84	0	294
NC7-daucus	1563	0	1262	81	78	967	566	30	1322	85	61	703
NC7-ocimum	106	0	99	93	93	93	13	0	100	94	0	71
NC7-parsnips	73	0	58	79	79	52	19	2	58	79	0	33
Totals	7954	0	5875	74	74	6609	1215	126	6718	84	404	3145

Acquisitions:
One expired PVP *Cucurbita pepo* PI 602592, 'Wee-B-Little', a miniature pumpkin developed by Novartis Seeds, Inc. Boise, ID was received from NLGRP. Four *Cucumis melo* var. *cantalupo* breeding lines were donated by J. D. McCreight: two aphid resistance lines; one line with resistance to papaya ringspot virus (PRSV), tolerance to watermelon mosaic virus, and complex resistance to powdery mildew (*Podosphaera xanthi*); one early flowering melon with a fractal architectural habit (multi-branching with short internodes).

Maintenance:
Data for vegetable crop regenerations attempted and number of accessions harvested in 2020 are summarized in the appendices in "Table 2: NCRPIS Accessions (Accs) Germinated, Regenerated, Made Available, Backed Up."

Regenerations:
Ames, Iowa experienced a derecho with 90+mph winds and over two inches of rain on August 10, 2020. Thirty *Cucumis* cages and or screens were destroyed, or the controlled pollination was compromised such that we were unable to rescreen and continue with insect pollinations of the accessions for the remaining three weeks of the pollination season. Fruit from these 30 cages were harvested early (within a few weeks of the storm) to ensure no open-pollinated fruits would be harvested. Screens of seven *Cucurbita* cages were blown completely off the frames, and thirteen other cages required extensive reburying of screens. Unlike *Cucumis*, *Cucurbita* produce relatively few female flowers which are receptive for only a few hours early each morning allowing us to remove female flowers that may have been compromised (open-pollinated) within the 20 *Cucurbita* cages damaged by the storm. Some

cucurbit vines were also damaged due to the strong winds tearing the tendrils from the screens and "rolling" the vines inside the cages, but many of the accessions had plants with a bush habit which sustained little or no damage. Damage would have been more severe had the *Cucurbita* cages not been somewhat protected by the maple windbreak along the west side of the field. Strong winds and heavy rain from the storm compounded lodging of some *Daucus* and *Cichorium* plants already experiencing poor root development due to drought conditions earlier in the season and may have impacted overall seed production on these two genera.

Availability of the *Cucumis sativus* (cucumber) collection is at 95% with only 68 accessions unavailable for distribution. Most of the unavailable accessions will require specialized regeneration protocols in the greenhouse, for which some protocols still need to be determined. Cucumber field cage regenerations in 2020 focused on accessions having distribution seed lots with low seed quantities, low viabilities, and/or were regenerated more than twenty years ago. Regeneration was attempted for 105 accessions. Ten accessions had poor or no germination and will be added to the 2021 regeneration queue. Seven accessions produced low seed quantities due to low fruit production or due to low numbers of seeds produced in each fruit. Four accessions had moderate seed quantities (2500 to 3500 seeds) because the fruits produced relatively few seeds only in the blossom end. The remaining 84 accessions produced between 3,500 and 70,000 seeds. Viability testing will be completed in April 2021. Cucumber seeds with high viability (90% or higher) typically exhibit a seed longevity of 25+ years, so these seed lots should last for many years at our standard order distribution quantity of 50 seeds per accession. Regenerations were attempted on 15 accessions of wild *Cucumis* species in the greenhouse with five producing good to excellent quantities of fruit/seed, four produced low quantities of fruit/seed, and six accessions failed to germinate. No *Cucumis melo* accessions were regenerated at the NCRPIS in 2020. Melons will not be regenerated in significant numbers until a reliable protocol is developed to deal with the seed transmitted bacterial fruit blotch (*Acidovorax citrulli*) disease.

Cucurbita pepo (pumpkin, squash) regenerations included 38 accessions in summer field cages and four accessions in the greenhouses during the winter. Regenerations were successful on three of the four late maturing accessions grown in the greenhouses with each accession yielding between 4,000 to 8,000 seeds. Further investigation is needed to determine why the fourth accession produced only two fruits from 44 hand pollinations. Field cage regenerations focused on accessions with low seed quantities or accessions with distribution lots 20-plus years old. Thirty-four of the field cages produced significant fruit quantities with 33 cages producing 55 or more fruit per cage. Twenty of these cages had between 100 and 250 fruit per cage. One accession had no fruit at harvest though both male and female flowers were present, and three accessions produced four or fewer fruits. These accessions will likely need to be regenerated in the greenhouse in the future.

Cucurbita fruits are harvested prior to or immediately after a killing frost, then stored until processing in November or December to allow the seeds to mature further. These fruits would generally be stored in multiple rubber garden trugs or hard plastic bushel baskets per accession in the NCRPIS "cave", but we did not have enough baskets or space in the cave to accommodate the impressive quantities of fruit produced in 2020.

Fred Engstrom (Farm Manager) and Cole Hopkins (Ag Specialist-Vegetables) suggested we use several 48" x 40" x 42.5" collapsible wire crates that had been purchased for another purpose. We were able to haul the crates on a flat rack to the field for harvest, then stack two crates high in a storage room until the seeds could be extracted. One wire crate was usually sufficient to hold the fruit harvested from one accession. Using these crates saved personnel a lot of work as the forklift was used for most of the heavy lifting. We purchased several additional smaller (48" x 40" x 31.5") wire crates which were also fitted with wheels to finish out the *Cucurbita* harvest. The wheeled crates made transporting fruits to the processing area more convenient. The wire crates were lined with a heavy plastic bag to prevent possible contamination and keep the facility clean in case fruits began to decline during storage.

Small (48" x 40" x 31.5") plastic lined wire crate with 59 fruit.

Large (48" x 40" x 42.5") plastic lined wire crate with 198 fruit.

The NCRPIS *Daucus* regenerations focused on wild species of *Daucus* including 28 perennials and 21 annuals. Regeneration protocols for many of the wild species are yet to be determined and there is little in literature to provide guidance. The perennial accessions (22 *D. crinitus* and six *D. setifolius*) from Morocco, Portugal, and Spain were planted in the greenhouse in early November 2019. Germination was very poor resulting in very small plant populations. The plants were maintained in the greenhouses where we have better control of environmental conditions. Flies and/or alfalfa leaf cutting bees were introduced into the cages as some accessions began to bolt in May and June of 2020, with only five accessions producing seeds. Accessions then went through a dormant period and began to flower again in October, but little seed was produced. We will continue to maintain the accessions in greenhouse cages through the spring and possibly the summer of 2021. We also planted six *D. pusillus* accessions for greenhouse regeneration, one of which died when the station lost power due to the derecho August 10th and the Farm Greenhouse-3 backup generator failed. In addition to the greenhouse regenerations, we also direct seeded 15 annuals into field cages. Three accessions failed to germinate, and one failed to bolt and flower so the plants were dug from the field for continued regeneration in the greenhouse over the winter. The remaining 11 field caged accessions were harvested and are being processed for storage. In addition to the Ames regenerations, we received substantial seed increases of six cultivated biennial accessions each from Laura Maupin, Seminis Vegetable Seeds (Bayer), Idaho and Rob Maxwell, Bejo Seeds, Idaho. The continued support of our cooperators' regenerations of cultivated, biennial *Daucus* germplasm allows the NCRPIS program to focus efforts on regenerating the more challenging wild, and unimproved accessions in the collection.

One accession of *Pastinaca* regenerated in 2019 failed to produce a sufficient quantity of seed and was regenerated again in 2020. If the 2020 increase lot has a good viability, it will be bulked with the 2019 seed lot and the resulting bulked lot will be made available for distribution.

As NCRPIS accessions are regenerated, backup seed samples are sent to the NLGRP in Ft. Collins. Backup samples of 184 accessions from the Vegetable Project were sent to the NLGRP in 2020. Overall, 84% of the accessions in the vegetable collections are backed up. Six of eight vegetable site-crops have 80% or more of their accessions backed up at NLGRP (Appendix Table 2). The NCRPIS has also sent an additional 4004 vegetable accessions for deposit in the Svalbard seed vault.

Distributions:
Packet and accession distributions for research and education for the vegetable collections are summarized in the appendices in "Table 3A: External NCRPIS Distributions". In 2020, 10,432 items (packets) involving 4,788 accessions were distributed to fulfill 164 orders (102 domestic, 62 foreign) for 136 unique recipients. Vegetable research requests received in 2020 specified objective topics as disease evaluations, breeding for specific traits and disease resistances, genetic and molecular studies, and diversity assessment for biotic and abiotic stress tolerance. Seed companies continue to request substantial numbers of accessions primarily from the cucurbit collections, but all available *Cichorium intybus* accessions were sent to one domestic seed company for breeding and research – a collection that doesn't typically receive much interest from other than home gardeners

Non-Research Requests (NRR) continue to make up a significant portion of orders received by the NCRPIS. There were 1687 orders classified as NRR in 2020, and 974 (58%) of these orders included request for germplasm accessions curated by the Vegetable Project. Very few of these requests are fulfilled.

Germinations:
In 2020, 1572 vegetable inventory lots were tested for viability (Appendix Table 2), with the majority of testing attributed to maintenance germinations of *Cucumis melo* and new increase lots.

Characterization and Taxonomy:
Digital images and basic notes for taxonomic identification and accession characterization were recorded during regeneration. Data for approximately 17 descriptors (primarily fruit descriptors) were recorded at harvest for *Cucumis* and *Cucurbita.* Plant habit, flowering dates, and life-cycle notes were recorded for *Daucus*. There will be a delay in loading of images and descriptor data for vegetable accessions to GRIN-Global until we are able to fill the Vice Clark Vegetable Tech position.

Taxonomic identities are reviewed and confirmed as each accession is regenerated. No taxonomic changes were submitted in 2020, but several are pending for *Cucumis* and *Daucus*.

Evaluation/Utilization:
We continue to screen all *Cucurbita* and *Cucumis* seedlings grown for regeneration for the presence of squash mosaic virus, using ELISA, before seedlings are transplanted to the field cages. All cucurbit field and greenhouse plantings are also visually inspected for disease during the growing season. Seed-borne diseases are of specific interest, with bacterial fruit blotch (*Acidovorax citrulli*) in *Cucumis melo* being of particular concern. Phytosanitary issues have prevented the distribution of *Cucumis* and *Cucurbita* germplasm to some countries. The Vegetable Project is working with the NCRPIS Pathology Project to develop a method to clean up infested seed lots and prevent transmission of seed borne diseases such as bacterial fruit blotch. The goal is to develop a seed treatment to eliminate the pathogen during the regeneration process which will enable us to secure disease-free seed lots for distribution.

The CucCAP Project (started in 2016) had three objectives: develop genomic approaches and tools for cucurbit species, perform genomic-assisted breeding to introgress disease resistance into cucurbit cultivars, and perform economic impact analyses of cost of production and disease control and provide readily accessible information to facilitate disease control. NPGS crop specific curators participated in the project providing information and guidance regarding the germplasm collections and the NPGS. For NCRPIS germplasm collections, CucCAP evaluations focused on disease resistance in *Cucumis sativus* (downy mildew, Phytophthora), *Cucumis melo* (powdery mildew, Fusarium, Cucumber Yellow Stunting Disorder Virus, Cucumber Mosaic Virus), and *Cucurbita pepo* (powdery mildew, Phytophthora, Papaya Ring Spot Virus, Cucumber Mosaic Virus). All genotype by sequencing (GBS) was completed for cucumber, melon and watermelon by April 2018. The GBS for the *Cucurbita*

collections were completed and the data made publicly available via the CucCAP website, though the data has not yet been published. Pursuit of phenotypic characterization of the cores is planned as part of CucCAP II. The project's website, https://cuccap.org/, posts a list of publications resulting from the research, and provides access to cucurbit genomics tools and databases via the Cucurbit Genomics Database website. All phenotypic data generated in the evaluation process will be referenced in or made available via the GRIN-Global database, and enhanced lines developed through the process may be made available through the NPGS.

Publications/Posters:
F. Martínez-Flores, M.B. Crespo, P.W. Simon, H. Ruess, K. Reitsma, E. Geoffriau, C. Allender, N. Mezghani, and D.M. Spooner. Subspecies Variation of *Daucus carota* coastal ("gummifer") Morphotypes (Apiaceae) Using Genotyping-by-Sequencing. Final revision submitted to Systematic Botany 01/09/2020.

Plans for 2021:
Regeneration efforts will be scaled back due to pandemic restrictions of field operations, reduced student labor availability, and the loss of our full-time Iowa State University technician with the retirement of Lucinda (Cindy) Clark who worked for the NCRPIS Vegetable Project for 21 years. Cole Hopkins, a shared half-time technician with the Farm Management Project, has been working more than 50% of his time with the Vegetable Project since Cindy left in January 2021.

Regenerations:
We will continue with the greenhouse regeneration of the perennial *Daucus setifolius* and *D. crinitus* accessions that were planted in November 2019. The 2021 field regenerations will include 25 biennial *Daucus* (planted in the greenhouse November 2020), 25 *Cichorium endivia*, 20 *Ocimum*, and approximately 100 *Cucumis sativus* and 25 *Cucurbita pepo*.

Three wild *Cucumis* species planted in 2019 continue to grow in the greenhouses including one accession each of *C. africanus*, *C. heptadactylus*, and *C. hirsutus*. The *C. heptadactylus* and *C. hirsutus* are dioecious species (having separate male and female plants) and were transplanted to field cages in 2020 after plants failed to flower and produce fruits. Both accessions set fruit in the field cages but had small populations so did not produce sufficient quantities of seeds. The plants were dug from the field cages and transplanted to pots in the greenhouse. Additional seeds were planted for each of the three wild Cucumis accessions to increase the populations. The *C. heptadactylus* and *C. hirsutus* will again be transplanted to field cages in 2021 and hopefully produce enough fruit and seed for a successful regeneration. In addition to the wild *Cucumis*, six *Cucurbita pepo* accessions were planted in the greenhouse for regeneration during the winter of 2020-2021.

The Vegetable Project will continue to collaborate with the Plant Pathology project researching new regeneration protocols for the cucurbit collections to produce pathogen free seed lots, primarily regarding the *Acidovorax citrulli* pathogen in the *Cucumis melo* collection.

Characterization:
We still have many years of fruit characterization data on cucurbits to be converted and loaded into GRIN-Global. Cindy Clark made significant progress renaming digital image files of seeds, plants, and fruits that have been acquired since 2013, but no images were loaded before her retirement on January 4, 2021. Loading these images will likely be delayed until a new full-time technician is hired to replace Cindy. Review of accession passport data will continue for the cucurbit and *Daucus* collections in preparation for assigning PI numbers to many of the Ames-numbered accessions in the collections (414 *Cucumis*, 88 *Cucurbita*, and 99 *Daucus*).

Evaluation:
We are still awaiting receipt of evaluation and characterization data resulting from the NPGS funded proposal "Phenotypic and molecular marker evaluation of carrot and wild *Daucus carota* germplasm recently added to the NPGS" submitted by Drs. Philipp Simon and David Spooner (USDA-ARS, Madison, WI) through the Root and Bulb Vegetable Crop Germplasm Committee (RBV-CGC) in 2014. Phenotypic evaluation for key carrot descriptors (storage root shape and color, annual - biennial flowering behavior, other RBV-CGC approved descriptors), and Alternaria leaf blight susceptibility will be collected on the 167 wild and domesticated carrot germplasm accessions collected for the NPGS from 2007 to 2013. Genotyping-by-sequencing (GBS) will be used to characterize the genetic diversity of the germplasm. These data will be integrated with other genomic data to study carrot genetics, domestication, speciation, and evolution. All phenotypic data collected will be loaded into GRIN-Global.

Data generated by the CucCAP (Project Director: Dr. Rebecca Grumet, Professor, Dept. of Horticulture, Michigan State Univ., East Lansing, MI) and the *Daucus* SCRI (Project Director: Dr. Philipp Simon, USDA-ARS, Vegetable Crops Research Unit, Madison, WI) will be loaded to GRIN-Global with the completion of the projects.

H. Research Leader Activities (D. Peters and C. Gardner)

Administration and Leadership Activities:
The RL administers the five-year project plan objectives for the USDA-ARS Plant Introduction Research Unit's two CRIS Projects, Plant Introduction Research, and the Germplasm Enhancement of Maize (GEM) Project and contributes to the coordination and execution of activities which support those objectives. Gardner served as RL until July 2020, when she entered phased retirement (half time employee), serving as the Coordinator of the Hatch-funded Multistate NC7 Project. She fully retired in December 2020 and now has collaborator status with USDA-ARS and with Iowa State University.

David Peters, the Unit's maize geneticist with the GEM Project, assumed duties as Acting Research Leader in July following Gardner's retirement. He was appointed to the permanent RL position in December 2020. He extends his sincere appreciation to the NC-7 RTAC members and other participants for their dedication to advancing conservation and utilization of plant genetic resources, and to enhancing the operations of the NCRPIS.

We wish to extend our gratitude to Dr. Amy Iezzoni for her many (XX) years of service as RTAC member from Michigan State University. Amy brought insights and breadth to the plant genetic resource community and is a master of integration of modern genetic technology with 'a feeling for the organism' to advance sour cherry development especially, and of many other crops. Gratitude is also extended to Dr. Terry Isbell of USDA-ARS-NCAUR, who served as a non-voting member. Terry developed many research partnerships with RTAC members and scientists from a wide variety of institutions that utilized plant genetic resources in novel ways, leading to commercialization of new crops and development of new uses.

Fiscal 2021 appropriations were fully available in 2021 following several continuing resolutions in the last quarter of 2020. Delays in release of funds create uncertainty for program planning and complicate completion of hiring and procurement, exacerbating administrative management overload throughout the system. Making timely decisions for work plans for many taxa that require germination and vernalization treatments in the winter is challenging under these circumstances.

In 2020 the pandemic added a new level of complexity for university and federal operations. Health and safety concerns were paramount; addressing these was guided by both ISU and USDA-ARS. Practices included such as sanitation, safe distancing, wearing of masks when in proximity to others (inside buildings in the field), and maximum telework were implemented. Field activities had to be greatly reduced across all curatorial and the GEM projects. Student hiring was reduced proportionately, and our stats indicate that fewer accessions were regenerated. Travel was generally not allowed, so collection trips were not possible. GEM was able to plant, manage, and harvest yield trial plots. We continued to distribute seed to US requestors but international requests requiring APHIS handling were substantially delayed. Many international requests were suspended because shipments could not be delivered to the recipients.

Gardner served on the advisory group for the Daucus SCRI Project, and on ISU graduate student committees. She served on the selection panel for a new geneticist/curator (hemp and vegetables) for the Geneva, New York Plant Introduction Station. About 10% of her time was devoted to assisting GRIN-Global System development team members, 15% to the GEM Project, and about 75% to genebank issues and SAES and other reporting commitments.

David Peters was rapidly immersed in the non-GEM activities of the genebank and learning the ropes of research unit administration. He served as the Coordinator of the Midwest GEM Project from July 2016 to December 2020 and will continue to manage the project until a new coordinator is located.

The derecho presented a new challenge. The station was fortunate in that Fred Engstrom and Brian Buzzell were able to cover the storm damage to the seed storage roof in a way that prevented further, interior damage. We are grateful to ISU for rapidly contracting and funding the roof replacement.

Scientific and curatorial personnel generally met with colleagues virtually as the station was closed to visitors and tours. Participation in scientific meetings was virtual as well.

2020-2021 Plans:
New five-year project plans for the NC7 Project and both ARS CRIS projects were approved in 2017. The current period of Hatch Multistate Project NC-007's is 10/01/2017-9/30/2022. The Project must be revised and submitted for renewal during 2021 for period 10/01/2022 – 9/30/2027. Dr. Peters is the NC-7 Project Coordinator and will work with NC-7 participants on drafting of the project proposal.

Review of the lease agreement between ISU and ARS immediately after the derecho storm in August 2020 revealed that the lease needs to be reviewed and updated. This will ensure that the lease properly reflects the current station activities, facility footprint, and maintenance responsibilities on the ISU experiment station site.

The VMEK Metrix optical sorter will continue to be used to experiment with sorting 'recipes' for a number of crops to explore quality improvement of seed lots. It offers a lot of promise.

We hope to reengage use of the QSorter from the Swiss company, QualySense, purchased with USDA-ARS Midwest Area and HQ support, captures 3D images and NIR spectra from seeds, and can sort seeds based on calibrations developed for specific traits or size/color parameters. The Covid-19 pandemic delayed progress in this area; the company plans to locate a research and development team in Ames.

Pete Cyr will continue to focus on development of RESTFUL interface applications to enable ready extraction of GRIN-Global information that can be combined with information from other resource providers (such as genomic information resources) by researchers.

We continue to focus on recruiting to fill vacant PIRU and NCRPIS positions with outstanding individuals, facilitate smooth transitions, and assist graduate students in completion and publication of their work. We will continue to use the ORISE program to hire contract employees to cover some aspects of our activities; plans are use this program to help fulfill development of learning/training objects to serve the objectives of the Higher Education Challenge Grant devoted to management and utilization of plant genetic resources.

Year 2020 Table 1. 01/01/2020 to 12/31/2020		NCRPIS Accessions (Accs), Acquired, Available					
CURATOR	GENUS_CROP	Number Accs	Number Accs Acquired	Percent Acquired	Number Available	Percent Available	Percent Avail Last Year
Brenner	NC7-grass.echinochloa	315	0	0.0%	283	90%	90%
	NC7-grass.misc	142	0	0.0%	83	58%	58%
	NC7-grass.panicum	936	0	0.0%	909	97%	96%
	NC7-grass.setaria	1116	1	0.1%	1016	91%	91%
	Subtotal Grasses:	**2509**	**1**	**0.0%**	**2291**	**91%**	**91%**
	NC7-legume.melilotus	1006	0	0.0%	868	86%	89%
	NC7-legume.misc	304	5	1.6%	162	53%	54%
	Subtotal Legumes:	**1310**	**5**	**0.4%**	**1030**	**79%**	**81%**
	NC7-pseudocereal.amaranth	3344	4	0.1%	3239	97%	97%
	NC7-pseudocereal.celosia	60	0	0.0%	39	65%	65%
	NC7-pseudocereal.perilla	25	0	0.0%	24	96%	96%
	NC7-pseudocereal.portulaca	13	0	0.0%	10	77%	77%
	NC7-pseudocereal.quinoa	848	199	23.5%	335	52%	63%
	Subtotal Pseudocereals:	**4290**	**203**	**4.7%**	**3647**	**89%**	**92%**
	NC7-spinach	413	0	0.0%	310	75%	76%
	NC7-umbels	1196	0	0.0%	810	68%	63%
	Brenner Total:	**9718**	**209**	**2.2%**	**8088**	**85%**	**86%**
Carstens	NC7-medicinals	1113	29	2.6%	775	70%	71%
	NC7-ornamentals	775	8	1.0%	546	70%	69%
	NC7-woody.landscape	2038	20	1.0%	1080	53%	52%
	Carstens Total:	**3926**	**57**	**1.5%**	**2401**	**61%**	**61%**
Marek	NC7-asters	457	2	0.4%	158	35%	35%
	NC7-brassica	2019	0	0.0%	1785	88%	84%
	NC7-crucifers	1307	0	0.0%	1132	87%	89%
	NC7-cuphea	638	0	0.0%	509	80%	80%
	NC7-euphorbia	210	0	0.0%	102	49%	49%
	NC7-flax	2834	0	0.0%	2816	99%	99%
	NC7-flax.wilds	167	0	0.0%	124	74%	74%
	NC7-sun.cults	2646	14	0.5%	2391	90%	92%
	NC7-sun.wilds.ann	1693	1	0.1%	1617	96%	95%
	NC7-sun.wilds.per	899	0	0.0%	762	85%	83%
	NC7-sun.wilds.sp	2	0	0.0%	0	0%	0%
	Subtotal Wild Sunflower:	**2594**	**1**	**0.0%**	**2379**	**92%**	**91%**
	Marek Total:	**12872**	**18**	**0.1%**	**11396**	**89%**	**88%**
Bernau & Millard	NC7-maize.coix&tripsacum	53	0	0.0%	8	15%	15%
	NC7-maize.gems	391	37	9.5%	357	91%	94%
	NC7-maize.inb	2682	0	0.0%	2200	82%	80%
	NC7-maize.pop	15891	47	0.3%	12167	77%	69%
	NC7-maize.pvp	510	95	18.6%	508	100%	100%
	NC7-maize.teosinte	439	0	0.0%	71	16%	17%
	Subtotal Zea:	**19913**	**179**	**0.9%**	**15303**	**77%**	**71%**
	Bernau & Millard Total:	**19966**	**179**	**0.9%**	**15311**	**77%**	**70%**
Reitsma	NC7-chicory	285	0	0.0%	254	89%	86%
	NC7-cucumis.cucs	1401	0	0.0%	1334	95%	95%
	NC7-cucumis.melo	3228	4	0.1%	1936	60%	60%
	NC7-cucumis.wilds	318	0	0.0%	207	65%	65%
	NC7-cucurbita	981	1	0.1%	725	74%	75%
	NC7-daucus	1563	0	0.0%	1262	81%	78%
	NC7-ocimum	106	0	0.0%	99	93%	93%
	NC7-parsnips	73	0	0.0%	58	79%	79%
	Reitsma Total:	**7950**	**5**	**0.1%**	**5875**	**74%**	**74%**
NCRPIS Total:		54432	468	**0.9%**	**43071**	**79%**	**77%**

Year 2020 Table 2. 01/01/2020 to 12/31/2020		NCRPIS Accessions (Accs) Germinated, Regenerated, Made Available, Backed Up													
CURATOR	GENUS_CROP	Number Accs	Number Accs Germed	Percent Accs Germed	Number Attempted Regen	Number Harvested Regen	Number Perm Perennial	Number Perennial Harvested (Vegetative)	Number Accs Growing	Number Accs Made Available	Number Accs Backed Up at NLGRP for YR	Number Accs Backed Up at Svalbard for YR	Number Accs Backed Up at Other Locations for YR	Total Number Accs Backed Up	Percent Accs Backed Up
Brenner	NC7-grass.echinochloa	315	2	1%	5	5	0	0	0	1	1	4	0	279	89%
	NC7-grass.misc	142	3	2%	5	6	0	0	0	1	0	0	0	94	66%
	NC7-grass.panicum	936	6	1%	7	7	0	0	0	13	10	14	0	916	98%
	NC7-grass.setaria	1116	40	4%	8	8	0	0	0	0	0	35	0	978	88%
	Subtotal Grasses:	**2509**	**51**	**2%**	**25**	**26**	**0**	**0**	**0**	**15**	**11**	**53**	**0**	**2267**	**90%**
	NC7-legume.melilotus	1006	19	2%	2	2	0	0	0	0	0	38	0	931	93%
	NC7-legume.misc	304	5	2%	4	7	0	0	0	2	0	0	0	218	72%
	Subtotal Legumes:	**1310**	**24**	**2%**	**6**	**9**	**0**	**0**	**0**	**2**	**0**	**38**	**0**	**1149**	**88%**
	NC7-pseudocereal.amaranth	3341	713	21%	117	55	0	0	0	64	62	47	0	3263	98%
	NC7-pseudocereal.celosia	60	0	0%	0	0	0	0	0	0	0	0	0	43	72%
	NC7-pseudocereal.perilla	25	20	80%	3	1	0	0	0	0	0	0	0	24	96%
	NC7-pseudocereal.portulaca	13	1	8%	1	0	0	0	0	0	1	0	0	10	77%
	NC7-pseudocereal.quinoa	650	65	10%	90	76	0	0	0	80	62	27	0	330	51%
	Subtotal Pseudocereals:	**4089**	**799**	**20%**	**211**	**132**	**0**	**0**	**0**	**144**	**125**	**74**	**0**	**3670**	**90%**
	NC7-spinach	413	116	28%	42	16	0	0	0	23	12	47	0	399	97%
	NC7-umbels	1196	108	9%	56	26	0	0	0	87	69	127	0	784	66%
	Brenner Total:	**9517**	**1098**	**12%**	**340**	**209**	**0**	**0**	**0**	**271**	**217**	**339**	**0**	**8269**	**87%**
Carstens	NC7-medicinals	1113	117	11%	24	35	1	0	0	6	12	51	0	820	74%
	NC7-ornamentals	775	26	3%	1	7	2	14	0	25	1	0	0	595	77%
	NC7-woody.landscape	2038	63	3%	14	33	31	14	0	37	1	0	0	945	46%
	Carstens Total:	**3926**	**206**	**5%**	**39**	**75**	**34**	**28**	**0**	**68**	**14**	**51**	**0**	**2360**	**60%**
Marek	NC7-asters	457	3	1%	0	0	0	0	0	1	1	0	0	176	39%
	NC7-brassica	2019	158	8%	5	79	0	0	0	133	91	57	0	1990	99%
	NC7-crucifers	1307	504	39%	19	14	0	0	0	11	10	46	0	1178	90%
	NC7-cuphea	638	0	0%	0	0	0	0	0	0	0	0	0	583	91%
	NC7-euphorbia	210	0	0%	0	0	0	0	0	0	0	0	0	99	47%
	NC7-flax	2834	179	6%	0	0	0	0	0	11	9	133	0	2832	100%
	NC7-flax.wilds	167	0	0%	7	0	0	0	0	0	0	22	0	141	84%
	NC7-sun.cults	2646	31	1%	94	87	0	0	0	39	16	208	0	2197	83%
	NC7-sun.wilds.ann	1693	49	3%	27	17	0	0	0	20	18	149	0	1598	94%
	NC7-sun.wilds.per	899	49	5%	0	0	0	0	0	32	26	98	0	751	84%
	NC7-sun.wilds.sp	2	0	0%	0	0	0	0	0	0	0	0	0	0	0%
	Subtotal Wild Sunflower:	**2594**	**98**	**4%**	**27**	**17**	**0**	**0**	**0**	**52**	**44**	**247**	**0**	**2349**	**91%**
	Marek Total:	**12872**	**973**	**8%**	**152**	**197**	**0**	**0**	**0**	**247**	**171**	**713**	**0**	**11545**	**90%**
Bernau	NC7-maize.coix&tripsacum	53	0	0%	0	0	0	0	0	0	0	0	0	13	25%
& Millard	NC7-maize.gems	391	66	17%	30	30	0	0	0	56	125	184	0	223	57%
	NC7-maize.inb	2682	284	11%	34	28	0	0	0	93	166	185	0	1603	60%
	NC7-maize.pop	15891	3393	21%	150	76	0	0	0	586	566	132	0	13141	83%
	NC7-maize.pvp	510	223	44%	101	99	0	0	0	33	9	0	0	509	100%
	NC7-maize.teosinte	439	1	0%	439	0	0	0	0	1	2	0	0	44	10%
	Subtotal Zea:	**19913**	**3967**	**20%**	**754**	**233**	**0**	**0**	**0**	**769**	**868**	**501**	**0**	**15520**	**78%**
	Bernau & Millard Total:	**19966**	**3967**	**20%**	**754**	**233**	**0**	**0**	**0**	**769**	**868**	**501**	**0**	**15533**	**78%**
Reitsma	NC7-chicory	285	20	7%	24	20	0	0	0	18	16	65	0	259	91%
	NC7-cucumis.cucs	1401	119	8%	105	95	0	0	0	86	81	113	0	1334	95%
	NC7-cucumis.melo	3224	1264	39%	1	0	0	0	0	1	0	140	0	2605	81%
	NC7-cucumis.wilds	318	20	6%	15	9	0	0	0	0	0	25	0	210	66%
	NC7-cucurbita	980	46	5%	41	42	0	0	0	22	15	0	0	828	84%
	NC7-daucus	1563	92	6%	43	34	0	0	0	110	72	61	0	1322	85%
	NC7-ocimum	106	4	4%	0	0	0	0	0	0	0	0	0	100	94%
	NC7-parsnips	73	7	10%	0	1	0	0	0	0	0	0	0	58	79%
	Reitsma Total:	**7950**	**1572**	**20%**	**229**	**201**	**0**	**0**	**0**	**237**	**184**	**404**	**0**	**6716**	**84%**
NCRPIS Total:		**54231**	**7816**	**14%**	**1514**	**915**	**34**	**28**	**0**	**1592**	**1454**	**2008**	**0**	**44423**	**82%**

Year 2020 Table 3. 1/01/2020 to 12/31/2020			External NCRPIS Distributions - Includes both DI (research and education), RP (Repatriation), OB (Observation), and NR (home garden) order types											
			External Domestic Distributions				Foreign Distributions				External Domestic and Foreign Distributions			
CURATOR	GENUS_CROP	Number Accs in Collection	Number Items	Number Accs	Number Orders	Number Recipients	Number Items	Number Accs	Number Orders	Number Recipients	Number Items	Number Accs	Number Orders	Number Recipients
Brenner	NC7-grass.echinochloa	315	17	14	8	8	46	43	5	5	63	53	13	13
	NC7-grass.misc	142	22	11	9	8	1	1	1	1	23	12	10	9
	NC7-grass.panicum	936	31	26	7	7	225	223	6	6	256	243	13	13
	NC7-grass.setaria	1116	298	247	24	22	47	45	6	6	345	273	30	28
	Subtotal Grasses:	**2509**	**368**	**298**	**35**	**30**	**319**	**312**	**15**	**13**	**687**	**581**	**50**	**43**
	NC7-legume.melilotus	1006	5	5	3	3	84	79	4	4	89	82	7	7
	NC7-legume.misc	304	14	13	4	3	2	2	1	1	16	15	5	4
	Subtotal Legumes:	**1310**	**19**	**18**	**6**	**5**	**86**	**81**	**5**	**5**	**105**	**97**	**11**	**10**
	NC7-pseudocereal.amaranth	3341	836	626	46	42	1150	900	10	10	1986	1206	56	52
	NC7-pseudocereal.celosia	60	13	11	6	6	4	4	2	2	17	12	8	8
	NC7-pseudocereal.perilla	25	1	1	1	1	0	0	0	0	1	1	1	1
	NC7-pseudocereal.portulaca	13	10	7	7	7	0	0	0	0	10	7	7	7
	NC7-pseudocereal.quinoa	650	1549	347	31	26	171	135	9	9	1720	347	40	35
	Subtotal Pseudocereals:	**4089**	**2409**	**992**	**72**	**60**	**1325**	**1039**	**19**	**19**	**3734**	**1573**	**91**	**79**
	NC7-spinach	413	1920	338	13	10	51	41	4	4	1971	338	17	14
	NC7-umbels	1196	597	382	16	15	398	374	15	15	995	454	31	30
	Brenner Total:	**9517**	**5313**	**2028**	**133**	**104**	**2179**	**1847**	**53**	**51**	**7492**	**3043**	**186**	**155**
Carstens	NC7-medicinals	1113	194	146	35	33	73	72	9	9	267	196	44	42
	NC7-ornamentals	775	47	44	21	20	61	60	9	8	108	100	30	28
	NC7-woody.landscape	2038	191	131	56	45	11	11	3	3	202	138	59	48
	Carstens Total:	**3926**	**432**	**321**	**102**	**82**	**145**	**143**	**15**	**14**	**577**	**434**	**117**	**96**
Marek	NC7-asters	457	13	11	5	5	7	6	4	4	20	17	9	9
	NC7-brassica	2019	1695	1290	51	39	1465	1434	14	14	3160	1712	65	53
	NC7-crucifers	1307	873	562	42	35	342	337	14	14	1215	773	56	49
	NC7-cuphea	638	4	4	2	2	53	53	1	1	57	57	3	3
	NC7-euphorbia	210	0	0	0	0	3	3	2	2	3	3	2	2
	NC7-flax	2834	109	109	4	4	73	73	3	3	182	178	7	7
	NC7-flax.wilds	167	214	147	4	4	124	118	4	4	338	147	8	8
	NC7-sun.cults	2646	522	416	47	33	4912	2485	30	29	5434	2485	77	62
	NC7-sun.wilds.ann	1693	267	197	22	19	1903	1584	20	17	2170	1592	42	36
	NC7-sun.wilds.per	899	62	58	13	13	969	748	13	12	1031	748	26	25
	NC7-sun.wilds.sp	2	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal Wild Sunflower:	**2594**	**329**	**255**	**30**	**25**	**2872**	**2332**	**22**	**19**	**3201**	**2340**	**52**	**44**
	Marek Total:	**12872**	**3759**	**2794**	**165**	**121**	**9851**	**6841**	**73**	**67**	**13610**	**7712**	**238**	**188**
Bernau & Millard	NC7-maize.coix&tripsacum	53	10	6	6	5	19	8	5	5	29	8	11	10
	NC7-maize.gems	391	503	296	45	32	350	282	13	13	853	347	58	45
	NC7-maize.inb	2682	3126	1421	213	164	2284	1216	83	76	5410	1809	296	240
	NC7-maize.pop	15891	2908	1926	209	156	1295	1100	40	33	4203	2382	249	189
	NC7-maize.pvp	510	2661	495	161	106	1101	403	55	46	3762	503	216	152
	NC7-maize.teosinte	439	160	47	50	39	99	53	8	8	259	63	58	47
	Subtotal Zea:	**19913**	**9358**	**4185**	**445**	**298**	**5129**	**3054**	**118**	**100**	**14487**	**5104**	**563**	**398**
	Bernau & Millard Total:	**19966**	**9368**	**4191**	**449**	**301**	**5148**	**3062**	**123**	**105**	**14516**	**5112**	**572**	**406**
Reitsma	NC7-chicory	285	152	141	8	5	24	24	3	3	176	148	11	8
	NC7-cucumis.cucs	1401	174	159	20	18	3144	1337	22	21	3318	1337	42	39
	NC7-cucumis.melo	3224	365	318	29	27	4032	1965	22	18	4397	1971	51	45
	NC7-cucumis.wilds	318	13	12	5	5	42	40	7	7	55	46	12	12
	NC7-cucurbita	980	236	174	23	21	699	628	11	11	935	651	34	32
	NC7-daucus	1563	537	451	16	13	56	51	3	3	593	478	19	16
	NC7-ocimum	106	485	99	18	15	368	99	7	7	853	99	25	22
	NC7-parsnips	73	39	28	4	4	66	58	3	3	105	58	7	7
	Reitsma Total:	**7950**	**2001**	**1382**	**102**	**83**	**8431**	**4202**	**62**	**53**	**10432**	**4788**	**164**	**136**
NCRPIS Total:		**54231**	**20873**	**10716**	**858**	**582**	**25754**	**16095**	**295**	**254**	**46627**	**21089**	**1153**	**836**

Year 2020 Table 4. 01/01/2020 to 12/31/2020		NCRPIS Accessions (Accs) Observations (Obs) in GRIN, Images in GRIN												
CURATOR	GENUS_CROP	Number of Accs in Collection	Number of Accs Obs Trials	Number of Obs in GRIN for Year	Number of Accs with Obs in GRIN for Year	Number of Obs in GRIN Last Year	Number of Accs with Obs in GRIN Last Year	Number of Obs in GRIN (all years)	Number of Acc with Obs in GRIN (all years)	Number of Accs Imaged	Number of Accs with Images in GRIN for Year	Number of Images in GRIN for Year	Number of Acc With Images in GRIN (all years)	Number of Images in GRIN (all years)
Brenner	NC7-grass.echinochloa	315	0	0	0	4	1	1167	305	9	20	44	75	174
	NC7-grass.misc	142	3	0	0	9	9	290	113	0	0	0	30	58
	NC7-grass.panicum	936	0	0	0	2723	936	4256	936	8	285	320	360	560
	NC7-grass.setaria	1116	0	0	0	582	154	4668	1078	27	241	382	345	693
	Subtotal Grasses:	**2509**	**3**	**0**	**0**	**3318**	**1100**	**10381**	**2432**	**44**	**546**	**746**	**810**	**1485**
	NC7-legume.melilotus	1006	0	0	0	250	50	7485	996	3	3	7	215	316
	NC7-legume.misc	304	0	0	0	0	0	547	244	40	40	42	74	99
	Subtotal Legumes:	**1310**	**0**	**0**	**0**	**250**	**50**	**8032**	**1240**	**43**	**43**	**49**	**289**	**415**
	NC7-pseudocereal.amaranth	3341	77	1185	96	867	74	56009	3329	2	5	18	1211	1975
	NC7-pseudocereal.celosia	60	0	0	0	0	0	164	56	1	1	1	21	49
	NC7-pseudocereal.perilla	25	1	0	0	0	0	86	25	1	16	32	22	49
	NC7-pseudocereal.portulaca	13	0	0	0	0	0	10	4	0	7	21	8	27
	NC7-pseudocereal.quinoa	650	4	1271	450	66	32	1886	450	201	366	420	470	641
	Subtotal Pseudocereals:	**4089**	**82**	**2456**	**546**	**933**	**106**	**58155**	**3864**	**205**	**395**	**492**	**1732**	**2741**
	NC7-spinach	**413**	**0**	**846**	**411**	**0**	**0**	**8883**	**413**	**411**	**411**	**443**	**411**	**492**
	NC7-umbels	**1196**	**0**	**1**	**1**	**1**	**1**	**6143**	**1146**	**7**	**9**	**24**	**212**	**385**
	Brenner Total:	**9517**	**85**	**3303**	**958**	**4502**	**1257**	**91594**	**9095**	**710**	**1404**	**1754**	**3454**	**5518**
Carstens	**NC7-medicinals**	**1113**	**0**	**5**	**5**	**0**	**0**	**11981**	**462**	**116**	**117**	**207**	**592**	**1316**
	NC7-ornamentals	**775**	**0**	**0**	**0**	**0**	**0**	**152**	**101**	**23**	**24**	**43**	**159**	**263**
	NC7-woody.landscape	**2038**	**3**	**84**	**50**	**0**	**0**	**4961**	**867**	**106**	**131**	**216**	**978**	**3006**
	Carstens Total:	**3926**	**3**	**89**	**55**	**0**	**0**	**17094**	**1430**	**245**	**272**	**466**	**1729**	**4585**
Marek	**NC7-asters**	**457**	**0**	**0**	**0**	**0**	**0**	**8**	**1**	**0**	**1**	**3**	**1**	**3**
	NC7-brassica	**2019**	**11**	**1239**	**166**	**0**	**0**	**41746**	**1996**	**85**	**85**	**89**	**418**	**1181**
	NC7-crucifers	**1307**	**0**	**0**	**0**	**4**	**2**	**7325**	**889**	**0**	**16**	**33**	**344**	**831**
	NC7-cuphea	**638**	**0**	**0**	**0**	**0**	**0**	**4260**	**278**	**0**	**0**	**0**	**13**	**34**
	NC7-euphorbia	**210**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6**	**18**	**6**	**18**
	NC7-flax	**2834**	**0**	**0**	**0**	**0**	**0**	**1717**	**285**	**0**	**45**	**128**	**46**	**129**
	NC7-flax.wilds	**167**	**0**	**0**	**0**	**0**	**0**	**852**	**82**	**0**	**0**	**0**	**2**	**2**
	NC7-sun.cults	**2646**	**18**	**0**	**0**	**0**	**0**	**104316**	**1826**	**14**	**115**	**407**	**356**	**1077**
	NC7-sun.wilds.ann	1693	0	0	0	0	0	40118	1307	0	24	77	89	201
	NC7-sun.wilds.per	899	0	0	0	0	0	13850	630	1	30	109	151	438
	NC7-sun.wilds.sp	2	0	0	0	0	0	0	0	0	0	0	0	0
	Subtotal Wild Sunflower:	**2594**	**0**	**0**	**0**	**0**	**0**	**53968**	**1937**	**1**	**54**	**186**	**240**	**639**
	Marek Total:	**12872**	**29**	**1239**	**166**	**4**	**2**	**214192**	**7294**	**100**	**322**	**864**	**1426**	**3914**
Bernau & Millard	**NC7-maize.coix&tripsacum**	**53**	**0**	**4**	**4**	**0**	**0**	**4**	**4**	**0**	**0**	**0**	**7**	**7**
	NC7-maize.gems	391	0	1976	358	1698	73	11145	360	69	43	60	196	876
	NC7-maize.inb	2682	71	14487	1701	8458	702	104682	2564	146	63	129	682	1567
	NC7-maize.pop	15891	4	15724	3543	7271	479	200599	13422	1386	805	1083	6836	12315
	NC7-maize.pvp	510	25	4449	551	4640	251	27073	561	99	117	458	529	3610
	NC7-maize.teosinte	439	0	57	43	0	0	273	127	1	0	0	107	115
	Subtotal Zea:	**19913**	**100**	**36693**	**6196**	**22067**	**1505**	**343772**	**17034**	**1701**	**1028**	**1730**	**8350**	**18483**
	Bernau & Millard Total:	**19966**	**100**	**36697**	**6200**	**22067**	**1505**	**343776**	**17038**	**1701**	**1028**	**1730**	**8357**	**18490**
Reitsma	**NC7-chicory**	**285**	**0**	**0**	**0**	**0**	**0**	**4700**	**279**	**5**	**5**	**5**	**262**	**918**
	NC7-cucumis.cucs	**1401**	**0**	**0**	**0**	**0**	**0**	**26149**	**1377**	**0**	**0**	**0**	**920**	**1231**
	NC7-cucumis.melo	**3224**	**8**	**0**	**0**	**0**	**0**	**12286**	**3196**	**0**	**0**	**0**	**649**	**1074**
	NC7-cucumis.wilds	**318**	**0**	**0**	**0**	**0**	**0**	**680**	**286**	**0**	**0**	**0**	**75**	**118**
	NC7-cucurbita	**980**	**0**	**0**	**0**	**0**	**0**	**5667**	**970**	**1**	**1**	**1**	**151**	**327**
	NC7-daucus	**1563**	**0**	**0**	**0**	**0**	**0**	**19502**	**1358**	**82**	**82**	**82**	**763**	**3235**
	NC7-ocimum	**106**	**0**	**0**	**0**	**0**	**0**	**635**	**98**	**0**	**1**	**4**	**14**	**21**
	NC7-parsnips	**73**	**20**	**0**	**0**	**0**	**0**	**153**	**71**	**0**	**0**	**0**	**1**	**1**
	Reitsma Total:	**7950**	**28**	**0**	**0**	**0**	**0**	**69772**	**7635**	**88**	**89**	**92**	**2835**	**6925**
NCRPIS Total:		**54231**	**245**	**41328**	**7379**	**26573**	**2764**	**736428**	**42492**	**2844**	**3115**	**4906**	**17801**	**39432**

Appendix Figure 1