ARS COLLECTIONS
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IMPORTANCE OF ARS COLLECTIONS

In the 53-year history of the Agricultural Research Service (ARS), collections have contributed to a number of groundbreaking discoveries and have had a significant economic impact on the agricultural community. Several ARS collections, such as the Department of Agriculture Nematode Collection (USDA-NC), the U.S. National Fungal Collection, and the U.S. National Insect Collection provide prompt support for the Animal and Plant Health Inspection Service (APHIS). Samples from these collections accessed by APHIS for diagnosis and investigation ultimately help the Nation to keep out invasive species and aid in the resolution of phytosanitary disputes that arise during the course of international trade.

In providing this critical support, ARS collections also play a significant role in enhancing economic opportunities for agricultural producers. USDA-NC, in Beltsville, Maryland, has contributed to this component of the ARS mission on several occasions. In 1970, nematode pests threatened the billion-dollar potato economy of the Pacific Northwest; after comparisons of pest specimens with archived specimens at USDA-NC, scientists determined that the source of the problem was a new nematode species and were thus able to make recommendations about crop rotations to save the industry. Similarly, in 2000, ARS scientists persuaded Brazilian officials to lift a ban on wheat imports by showing that U.S. wheat exports were free of a quarantined nematode. This demonstration, which kept open the $70M/year Brazilian wheat export market, was made possible with the use of ARS' thorough and well-preserved collection of nematodes.

Moreover, the scope of ARS collections extends beyond the Agency. A number of current collections predate the formation of ARS, and many are used by scientists around the globe. The National Plant Germplasm System (NPGS), for example, is one of the largest distributors of germplasm in the world. NPGS conserves more than 472,000 accessions, representing a wide variety of categories of plants, and annually distributes approximately 120,000 of these to external researchers. The taxonomy for NPGS is world class, with one full-time scientist devoted to managing the taxonomic index of the system. For each germplasm accession, a range of data, including passport, taxonomic, descriptor, observation, evaluation, and inventory data, is in the Germplasm Resources Information Network (GRIN), a database available online for public access. GRIN contains information on all genetic resources preserved by NPGS, including accessions of both domestic and foreign origin. NPGS contributes tremendously to scientific research efforts and provides a valuable service to the scientific community; the system furnishes the raw material for crop improvement worldwide, thereby helping to underpin global food security. Estimating conservatively, economists have indicated that the cost/benefit ratio of maintaining germplasm accessions is between 1:36 and 1:61; others have estimated that over 20 years, 1,000 additional accessions would be valued at $325M, or $325,000 per accession. By both estimates, the total value and worth of NPGS is substantial.

TYPES OF ARS COLLECTIONS

ARS possesses hundreds of diverse collections at research locations throughout the Nation. These include various culture (or living organism) collections, specimen-based (non-living

organism) collections, and non-organismal object collections. The collections divide generally into 18 categories (see insert). For the majority of these categories, ARS maintains several collections across the Nation, each with its own research purposes, strengths, and difficulties. ARS collections play a variety of roles and serve scientific research and development communities in a multitude of ways. Generally speaking, each collection serves as one or more of three types of collection: research collection, core or reference collection, or genetic resource "genebank" collection.

Research Collections

These collections, which may encompass living or non-living samples, have been assembled by ARS research units to enable an "in-house" ARS project or unit to address its assigned research objectives. These collections may be small, but are often critical to attaining those objectives. An example is the plant virus and viroid collections held at various ARS research locations throughout the Nation. These collections include potato virus Y isolates, vegetable and sugarbeet viruses, citrus tristeza viruses, and cereal viruses used to support ARS research on the genetics, genomics, and diagnostics of the viruses.

Categories of ARS Collections (primarily defined by taxa)

Bacteria
Fungi
Nematodes
Parasites and vertebrate protozoa
Invertebrate protists
Invertebrate viruses and cell cultures
Plant viruses and viroids
Vertebrate viruses
Invertebrate germplasm
Invertebrate systematics
Vertebrate germplasm
Plant germplasm and systematics
Plant genetic stocks
Human tissues
Natural resources
Chemicals
Molecular reagents
Overseas laboratory collections

Core/Reference Collections

These collections, which may include living or non-living samples, have usually been assembled, managed, preserved, and funded over many decades, with the objective of serving as international resources for microbial, plant, insect, parasite, and animal research. Core collections are not only broad but old, and they are critical to the continuity of specific scientific disciplines. They often serve as critical reference vouchers for systematic and taxonomic research. For many of these collections, funding is allocated specifically for distributing samples, without charge or restriction, to researchers and breeders on request. Information about the samples for many of these collections is available publicly on the Internet. The National Fungus Collection, for instance, is a core collection with over one million accessions and serves as an important resource for scientists around the world. Scientists have used nearly 100-year old herbarium specimens from this collection for DNA analysis to trace the spread of citrus canker, providing significant aid to plant quarantine policy makers.

Genetic Resource Collections "Genebanks"

Genetic resource collections have been assembled, managed, preserved, and funded, often over many decades, with the objective of serving as international resources for crop, beneficial insect, microbial, and livestock research and breeding, or for microbial research. Their purpose is to maintain in perpetuity the essential genetic materials (species, varieties, lines, etc.) that underpin microbial, crop, or livestock scientific research and genetic improvement worldwide. Their inventories consist of living organisms—plant seeds or propagules, animal herds, eggs, or semen,

insects (live or cryopreserved) and their semen, and/or microbial cultures. Researchers and breeders may request samples without charge or restriction, and may access information about the samples through publicly accessible databases on the Internet. For example, these collections include the component genebanks of the U.S. National Plant Germplasm System, the U.S. National Animal Genetic Resources Program, and the ARS Culture Collection.

ARS OVERSEAS/MONTPELLIER COLLECTIONS

ARS operates four overseas laboratories that conduct research in support of U.S. biocontrol research programs. Each of the laboratories has had a positive impact on U.S. agriculture through the collection, identification, release, and establishment of one or more biocontrol agents. Cumulatively, these agents have produced billions of dollars of benefit through increased yields, lower production costs, and reduced environmental contamination. The collections at the four laboratories, though small in comparison to U.S. collections, are unique and invaluable to biocontrol researchers.

The largest and longest-operating of these laboratories is the European Biological Control Laboratory (EBCL) in Montpellier, France; EBCL maintains a number of working collections consisting of arthropod natural enemies for biocontrol of weeds and insects. These collections are maintained by individual researchers as a part of specific projects. EBCL also has a pathogen collection consisting of approximately 2,000 living specimens collected over the past 20 years, acquired from a variety of countries for use as potential biocontrol agents for target insects and weeds. This collection is nearly completely identified, catalogued, and accessible through an electronic database.

ANALYSIS OF ARS COLLECTIONS

ARS collections, particularly the large collections, play a critical role in supporting both Agency research as well as research conducted by other institutions in North America and internationally. In recent years, the U.S. Administration has increasingly recognized this fact, identifying the stewardship of Federal scientific collections as one of two top special priorities for Federal agencies in 2005 and 2006. The Office of Science and Technology Policy (OSTP) authorized the formation of an Interagency Working Group on Scientific Collections to assess the status of all object-based Federal scientific collections, as they form part of the Nation's scientific infrastructure. OSTP, along with the Office of Management and Budget, directed Federal agencies to improve their collections care and ensure the existence of adequate management policies for them. As a result, ARS developed a taskforce to assess the current status of the Agency's collections and prepare recommendations for improving their maintenance. According to the taskforce's analysis, the status and condition of ARS collections varies widely.

Most Common Needs of ARS Collections

- Expanded/Upgraded Facilities
- Additional Staffing
- Succession Planning and Training for Curators
- Greater Accessibility of Materials and Information
- Updated Molecular Characterizations and Identification Tests
- Written Policies and Procedures
- Duplication of Resources at Larger ARS Repositories
- Increased Acquisitions

Status/Needs of Collections

The fiscal and physical status of collections and the quality of the curation varies widely among collections. Variation results from changing priorities for the area of research that the collections support and variation in the recognition of the importance of specific collections for solving agricultural problems. In ARS, the National Germplasm System (plants, animals, and microbes) is seen as a core activity that widely supports agriculture in the United States and abroad and constitutes a "program" in its own right. The program is adequately funded and is a priority for support. Other collections serve areas in which ARS has a shrinking program and which have less demand by customers but nonetheless are important to stakeholders. An example is the National Parasite Collection, which serves a large national and international community but is not a priority research area for ARS. Resources available for curation of such collections are eroding due to increasing costs in the face of flat budgets. Critical needs for scientific organizations such as ARS are strategies to maintain high priority collections while seeking to preserve the value of collections for which adequate curation funds are unavailable.

General Goals and Objectives for Collections

ARS has identified the following top 10 objectives to improve the Agency's capacity to serve the agricultural and scientific communities:

- Improve preservation practices*
- Ensure adequate curation and support staff
- Increase duplications across units to prevent loss of valuable/unique accessions*
- Ensure adequate facilities
- Increase acquisitions*
- Create electronic databases of accessions*
- Increase clarity and protocol for pathogen transportation*
- Ensure accurate identification of collected objects*
- Create policies and procedures for each collections-holding unit*
- Review status and needs of collections regularly*

*Indicates a potential area for international cooperation

Goals for ARS Genetic Resource Collections

Genetic resource collections in particular are the foundation of the Nation's agricultural future, containing invaluable sources of genes for new and improved traits; however, these collections need to be made more accessible in order to facilitate crop improvement. To spur future progress, ARS plans to develop an index of DNA sequence information and observable traits in the plant collections to allow rapid identification of varieties and lines with genes for important traits. Indexing involves three aspects: developing a comprehensive phenotypic evaluation of the germplasm in the collections; developing a set of DNA-based markers to define the genetic uniqueness of the entries in the collections; and, linking the markers with the phenotypes. This information will enable plant breeders to use the markers to identify the correct germplasm without using the typical trial and error approaches.

Similarly, livestock, poultry, and aquatic species genetic resources hold tremendous potential for the long-term improvement of our animal agriculture systems. ARS' breeding lines of beef and dairy cattle, swine, sheep, poultry, bees, and important aquaculture species must be phenotyped for desired traits such as efficiency of nutrient utilization, resistance to stress and disease, animal

longevity, and adaptation to the production environment. By phenotyping and genotyping animal populations, ARS can develop the ability to incorporate molecular genetic information into national genetic evaluation programs for livestock, beneficial insects, and aquaculture.

International Germplasm Exchange

During the last 25 years, the norms for exchanging agriculturally-important germplasm, especially for plants, have shifted markedly. In the past, plant genetic resources from nature, farmers' fields, and public genebanks were considered international common property, part of a "global commons." In general, plant genetic resources were exported upon request and without restriction, subject only to the need for phytosanitary permits in certain cases and the normal technical constraints of supply and managerial capacity.

In recent years, and for several reasons, international genetic resource exchange has become more formal, complicated, and restricted. One contributing factor is the need for more stringent phytosanitary regulation due to biosecurity and invasive species concerns. Another factor is that, increasingly, an inequity has been perceived between the benefits accrued by those granting access versus those enjoyed by those granted access. In some nations, there is widespread alarm about unauthorized and indiscriminate germplasm collecting and about unwarranted grants of intellectual property rights (IPR) protection for genetic resources. As a result, there is a trend for increasing IPR protection for genetic resources, and gaining access to these resources from the field, genebanks, and commercial sources is becoming increasingly difficult.

Two international treaties, the Convention on Biological Diversity (CBD) and the FAO International Treaty on Plant Genetic Resources (IT) have markedly affected recent national and regional laws that regulate access to germplasm. These treaties have given nations sovereignty over genetic resources under their jurisdiction, and stipulated that access to germplasm should be based on "prior informed consent" accompanied by the fair and equitable sharing of non-monetary and monetary benefits, in accordance with mutually agreed terms.

In the future, the norms for international germplasm exchange will continue to evolve in concert with global trends in access and benefit-sharing practices and policies. These changes will likely affect the manner in which the NPGS and other USDA/ARS genebank collections and germplasm exchange programs expand. The NPGS will continue to strive to fill gaps in its collections, but progress may be slow.

The advent of e-mail and database accessibility via the Internet, and the development of air courier companies with reliable and affordable service, have made ordering germplasm electronically and distributing it internationally via air transport commonplace. During the last decade, the NPGS exported an average of six accessions to other nations for every new accession acquired, and this 6:1 ratio may increase in coming years as demand from developing nations such as Brazil, China, and India continues to rise.

International Collaboration to Improve Collections

Internationally, there is much common concern over the care and funding of collections as well as providing access to collections for researchers from around the globe. Increasingly, major

collections, such as some of those held by ARS, are being looked to as global resources that cannot be duplicated elsewhere.

In December 2005, Dr. Jack Marburger, the President's Science Advisor, chose the topic of scientific collections as his discussion topic for the Organization for Economic Co-operation and Development (OECD) Global Science Forum (GSF) meeting. In 2006, the GSF approved the organization of an international workshop to be held in the Netherlands in June 2007. Topics at the workshop will include the following: 1) status and performance indicators for collections; 2) common policies on missions and priorities; 3) networking of collections; 4) cross-border access to collections. Dr. Phyllis Johnson and Dr. David Evans, co-chairs of the U.S. Interagency Working Group on Scientific Collections, have been invited to attend the workshop and present results of the U.S. survey of Federally-held, object-based scientific collections. The creation of common electronic indexing systems and database portals for collections will greatly facilitate global access and networking, as well as guide future exploration and collection, but will be a complex and expensive endeavor.

ARS has taken the lead on developing new technology (in partnership with the private sector) for Internet-operable high performance microscopy that has led to the current placement of three instruments in Washington, D.C. (ARS lab at the Smithsonian Institution), London (British Museum), and Paris (Natural History Museum). This technology allows a researcher in one location to have a specimen mounted in a scope at one of the other locations, and to manipulate it and take data and photos as if on-site. Expansion of the remote microscope network is anticipated. The network is expected to help address global access issues and reduce the need to travel to a collection to see a specimen. Historically, specimens have been loaned out via mail to researchers who need them, but this is risky for the specimens, and most institutions are stopping the practice.

Other international collections efforts include the Major Systematic Entomology Facilities (MSEF). MSEF is formed of the heads of major collections, and involves Canada, the United Kingdom, France, and the United States, among other nations. ARS also works with the Canadian agricultural department (Agriculture and Agri-Food Canada) to exchange specimens and participate in other collections activities. In addition, France is heavily involved in an effort known as the European Distributed Institute of Taxonomy (EDIT), which includes 27 leading institutions in Europe. The goal of the project, beginning in March of 2006 and scheduled to end in 2011, is to develop an improved understanding of biodiversity to improve conservation efforts.

FUTURE OF ARS COLLECTIONS

In the future, ARS' role with respect to collections will become increasingly critical as globalization and heightened biosecurity place additional pressures on collections holders. ARS is convinced that biological collections are an essential infrastructure underpinning research dedicated to solving problems associated with the nation's agriculture and environment, and the Agency will seek to enhance its role as the principal Federal agency with responsibility for agricultural collections.