

Background on the development of the “Global Strategy for the *Ex Situ* Conservation and Utilization of Maize Germplasm”

- Dr Major Goodman, from the Crop Science Department, North Carolina State University, Raleigh, USA, facilitated the process of developing the global maize ex situ conservation strategy.
- A survey of collections, content and status of conservation was undertaken in March - April 2006. A meeting of the key experts and curators took place 2-5 May 2006 at the International Maize and Wheat Improvement Center (CIMMYT) in Mexico.
- The strategy was finalised in November 2006 and reviewed during the period from December 2006 - August 2007.
- The process was funded by the Grains Research and Development Corporation (GRDC), Australia.

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Global Strategy for the *Ex situ* Conservation and Utilization of Maize Germplasm



Photo courtesy of Ing. Mario Fuentes, Maize Genebank Manager, Guatemala. Maize ear drying of highland landraces.

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Table of contents

DISCLAIMER	4
ACKNOWLEDGMENT	4
1. INTRODUCTION	5
2. BACKGROUND	6
3. NETWORKS	6
4. OVERVIEW OF ‘MAJOR’ COLLECTIONS	7
4.1 GERMLASM COLLECTIONS	7
4.2 GENETIC STOCK COLLECTIONS	9
5. THE IMPORTANCE - AND THE UNIQUENESS – OF THE INDIVIDUAL COLLECTIONS	9
6. CONSERVATION STATUS	11
6.1 STORAGE FACILITIES, SEED EXCHANGE AND DATABASE MANAGEMENT	11
6.2 SAMPLE SIZES	11
6.3 REGENERATION STATUS	11
6.4 DUPLICATION STATUS	11
6.5 DATA AVAILABLE	11
7. COLLECTIONS THAT FAIL TO MEET ACCEPTED GUIDELINES CONCERNING CONSERVATION STANDARDS	12
7.1 DEVELOPMENT OF CORE SUBSETS	12
7.2 MOLECULAR DATA	13
7.3 DISTRIBUTION OF DNA SAMPLES	13
7.4 GERMLASM MANAGEMENT AND BREEDING	13
7.5 MAIZE RACES IN THE REGIONS	13
7.6 REGENERATION VS. RE-COLLECTION	14
8. DISTRIBUTION STATUS	14
8.1 AVAILABILITY OF SEEDSTOCKS	14
8.2 ACCESSIBILITY	14
8.3 PHYTOSANITARY REQUIREMENTS	14
8.4 PAST EXPERIENCE	15
9. ANALYSIS OF WHICH COLLECTION HOLDERS ARE UNABLE TO READILY MAKE MATERIAL AVAILABLE INTERNATIONALLY	15
10. SYNTHESIS OF CONSERVATION AND DISTRIBUTION	15
11. MAJOR COLLECTIONS NOT MEETING STANDARDS	16
11.1 EXTENT TO WHICH THE DIVERSITY WITHIN THE COLLECTION IS, OR IS NOT, ALREADY REPRESENTED WITHIN A COLLECTION THAT MEETS THE STANDARDS FOR CONSERVATION AND DISTRIBUTION	16
11.2 IMPORTANCE OF ANY DIVERSITY NOT ALREADY REPRESENTED	16
11.3 SPECIFIC REQUIREMENTS FOR COLLECTIONS TO BE ABLE TO MEET THE STANDARDS FOR CONSERVATION AND DISTRIBUTION	16
12. IDENTIFY ANY OTHER COLLECTION THAT WAS NOT INCLUDED AMONG THE ORIGINAL SET OF ‘MAJOR’ COLLECTIONS BUT THAT NEVERTHELESS HAS IMPORTANT GENETIC DIVERSITY	16
13. POTENTIAL IMPROVEMENTS FOR COLLECTIONS THAT MEET STANDARDS	17
13.1 SPECIFIC ACTIONS THAT COULD BE UNDERTAKEN IN THE SHORT TERM TO INCREASE THE EFFICIENCY AND EFFECTIVENESS OF CONSERVATION COLLECTIVELY	17
13.2 A PROCESS TO BE FOLLOWED FOR IDENTIFYING OTHER POTENTIAL AREAS OF NEED OR IMPROVED EFFICIENCY	17
13.3 WAYS IN WHICH COOPERATION PER SE MIGHT BE ENHANCED, E.G. THROUGH A STRENGTHENING A SPECIFIC CROP OR OTHER NETWORK.	17
14. PLAN OF ACTION	19
14.1 GLOBAL ACCESSIONS MANAGEMENT: IDENTIFIERS, ESSENTIAL METADATA, AND STANDARDIZATION	19
14.2 GLOBAL AND REGIONAL COOPERATIVE NETWORKS AND AVAILABILITY OF SEED ACCESSIONS	20
14.3 GLOBAL AND REGIONAL EX-SITU CONSERVATION NETWORK: REGENERATION AND SAFETY BACKUP	20
14.4 COLLABORATION ON MAIZE GERMLASM CONSERVATION AND CAPACITY BUILDING OF MAIZE GERMLASM SPECIALISTS	21
14.4 GERMLASM CONSERVATION AND MANAGEMENT NEED TO BE INTEGRATED TO IMPROVE AGRICULTURAL PRODUCTIVITY	21
14.5 IMPROVED ACCESS TO CONSERVED GERMLASM	23
14.6 CONSERVATION OF WILD RELATIVES OF MAIZE: TEOSINTE AND <i>TRIPSACUM</i>	23
15. CONCLUSIONS AND CONSEQUENCES	23
15.1 ACCESS TO IMPROVED MATERIAL AND CROP IMPROVEMENT	23

15.2 SAFETY DUPLICATION	24
15.3 FILLING GAPS IN COLLECTIONS	24
15.4 TRAINING IN MAIZE GENETIC RESOURCES	24
15.5 MAIZE WILD RELATIVES	25
15.6 GLOBAL MAIZE GENETIC RESOURCES REGISTRY	25
LITERATURE CITED	26
APPENDICES	27
APPENDIX 1: SURVEY OF THE MAIZE COLLECTION INFORMATION IN MAIZE CROP STRATEGY DEVELOPMENT	27
APPENDIX 2: LIST OF COLLECTION MANAGERS CONTACTED THROUGH A SURVEY	30
APPENDIX 3. GLOBAL MAIZE GENETIC RESOURCES CONSERVATION MEETING, 5-6 MAY 2006	32
APPENDIX 4 PARTICIPANTS IN THE MAIZE GERMPLASM NETWORK MEETING, CIMMYT, MAY 2006	33
APPENDIX 5: THE WILD RELATIVES OF MAIZE	36
APPENDIX 6: SUMMARY OF THE QUESTIONNAIRE ON THE MAIZE COLLECTIONS	42
APPENDIX 7: SUMMARY OF THE QUESTIONNAIRE ON MAIZE COLLECTIONS BY WORLD REGIONS	53
APPENDIX 8: SUMMARY OF THE QUESTIONNAIRE ON SEED STORAGE CONDITIONS	54
APPENDIX 9: SUMMARY OF THE QUESTIONNAIRE ON SEED EXCHANGE POLICY AND INFORMATION DATABASES	57
APPENDIX 10: STANDARDS FOR MEDIUM- AND LONG-TERM STORAGE	62
APPENDIX 11: ACRONYMS USED IN THIS DOCUMENT	63

DISCLAIMER

This document has been developed by the crop experts. The objective of this document is to provide a framework for the efficient and effective *ex situ* conservation of the globally important collections of maize.

The Global Crop Diversity Trust (the Trust) provided support towards this initiative and considers this document as a critical framework for guiding the allocation of its resources. However the Trust does not take responsibilities for the relevance, accuracy or completeness of the information in this document and does not commit to funding any of the priorities identified.

This strategy document is expected to continue evolving and being updated as and when information becomes available. The Trust therefore acknowledges this version dated September 2007.

In case of specific questions and/or comments, please direct them to the strategy coordinator mentioned in the document.

Acknowledgment

This report has been made possible by the collaboration of maize germplasm bank managers worldwide, who completed several survey questionnaires upon which several parts of this report are based. Ing. Victor Chavez Tobar and Ms. Alejandra Arias, CIMMYT maize genetic resources, should be recognized for compiling the survey data. Besides, in completing the survey and the maize strategy it was a part of the requisite to include the current summary and future strategy for teosinte and tripsacum. For that, Dr. Jesus Sanchez Gonzalez and Dr. Denise Costich are especially acknowledged for their contributions in the appendix sections.

We applaud the Global Crop Diversity Trust for spearheading the development of this, and related, crop conservation strategy, and the interest and support given by the Grains Research and Development Corporation (GRDC) throughout this process.

Summary

The genetic resources of maize constitute an immeasurable treasure for humankind. Conservation of maize germplasm and knowledge about its variation and uses provide (i) resources for agricultural improvement to reduce hunger and poverty and (ii) a solid knowledge base for future generations of researchers and technological users. The variability among maize landraces exceeds that for any other crop. The collection and study of the accessions of the races of maize are unprecedented in man's agricultural heritage; their maintenance and regeneration has been remarkable, and their widespread and open availability to research workers has been unique (Tabata, 2005). Nonetheless, problems remain:

1. Integration of maize germplasm resources and maize breeding is challenging; historically, efforts have been inconsistent.
2. Most racial studies of maize have been New-World-oriented.
3. Regeneration of some eco-specific accessions has been difficult.
4. Distribution of individual seed requests via national germplasm banks has generally been ineffective due to resource and/or policy issues.
5. Phytosanitary restrictions are a major bottleneck in distributing germplasm samples.
6. Teosinte populations are endangered and have scattered (and less than complete) representation in the major international germplasm banks.
7. Documentation of the materials held in national collections is inconsistent, and sometimes poor, and is held in multiple databases that are not necessarily well maintained or easily accessible.
8. *Tripsacum* populations are part of the secondary gene pool of maize genetic resources, and some are endangered; some populations should be monitored and conserved.
9. Developing a worldwide strategy for preservation, documentation, distribution, and utilization of maize genetic resources will require attention to these and other, generally less difficult, problems.

1. Introduction

The process of developing the proposed strategic approach began in February 2006 with requesting the expertise of Dr Major Goodman of the Crop Science Department, North Carolina State University, Raleigh, USA to facilitate the development of a global conservation strategy for maize. The process began with data compilation and analysis of the status of existing maize collections complemented through a survey (format in Appendix 1) to the major maize collection managers (listed in Appendix 2). The information on the holdings of maize was obtained from the Bioversity International Database of Germplasm Collections. A summary of the results of the survey is included in Appendices 6 to 9.

Following from the survey, an expert meeting was held at CIMMYT in Mexico, 5-6 May 2006 (Programme in Appendix 3 and list of participants in Appendix 4). The discussions at the meeting guided the development of the approach suggested herein. The strategy consultation meeting was preceded by a workshop, "Latin American Maize Germplasm Conservation: Regeneration, *In situ* Conservation, Core Subsets, and Prebreeding," 2-4 May 2006 at CIMMYT, where worldwide representatives of maize germplasm collections were invited.

A steering committee consisting of Major Goodman (North Carolina State Univ., USA), J. Manuel Hernandez C., (INIFAP, Mexico), J. Jesus Sanchez G. (Univ. Guadalajara, Mexico), Ricardo Sevilla P. (Univ. National Agraria La Molina/INIA, Peru), and Suketoshi Taba (CIMMYT), assisted by Brigitte Laliberté (Global Crop Diversity Trust), gathered opinions from other attendees and made preliminary suggestions for a global maize conservation strategy.

2. Background

Maize was domesticated in southern or southwestern Mexico, most likely from teosinte or some extinct wild maize very closely related to teosinte (Wilkes, 2004; Sluyter and Dominguez, 2006). Maize is highly variable morphologically and is grown from sea level to 3800 m. Maize and the diploid teosintes, both with $2n=20$, are interfertile (there is one species of perennial, tetraploid teosinte). While maize covered much of the New World at the time of colonization, the teosintes have a much more restricted geographic distribution; mainly central and southwestern Mexico, with limited populations in northern Mexico, Guatemala, and Nicaragua (see Appendix 5). Maize has been divided into about 300 landraces (summarized in Goodman and Brown, 1988, but recently published in full on searchable CDs by the USDA and the North Central Regional Plant Introduction Station at Iowa State University, 2005 [USDA-ARS, 2005]). The maize of commerce represents only a fraction of the 300 or so landraces. The commercial landraces are the Northern Flints, Southern Dents, and Corn Belt Dents from the US, Tuxpeño and Celaya from Mexico, Cuban Flint from Cuba, Coastal Tropical Flint/Costeno and Tuson/Puya from the Caribbean and northern South America, Cateto and Cristal from Brazil and Argentina. Several early-maturing landraces from the Caribbean area probably were responsible for the early spread of maize into southern Europe; these were most likely Early Caribbean from the islands and Nal-tel de Tierra Baja from Guatemala. These few commercial landraces, which represent perhaps 5 to 10% of the landraces of the New World, were the sources of the bulk of the maize germplasm that reached and spread throughout the Old World. Teosinte was originally divided into 6 races by Wilkes (1967), but since the discovery of *Zea diploperennis*, species and subspecies names have come into favor (Wilkes, 2004; Appendix 5 of this document) for teosinte. While some races of maize (mostly lowland and mid-elevation races in areas where modern commerce prevails) have been displaced by modern cultivars, and others are threatened, virtually all the teosintes are endangered as a result of modern farming and ranching practices. In areas where populations of Native Americans predominate, their landraces of maize are still being cultivated and can still be collected today. However, economic forces, such as the North America Free Trade Agreement (NAFTA), are seriously eroding the well being of the small farmers in Mexico with a resulting serious reduction in the number of landraces being grown and a reduction of land area devoted to most races. In addition to maize and teosinte, there is one other genus of consequence related to maize. Some species of the genus *Tripsacum* (suggested base chromosome number $2n=18$ (Anderson, 1944; Stebbins, 1950), but actually represented by a polyploid series with some apomixis) can be crossed with maize (with difficulty), usually resulting in sterile progeny, but backcrosses to maize are possible. *Tripsacum*'s range is somewhat less than maize, but much greater than teosinte. There are at least 16 species of *Tripsacum*, ranging from the USA to Bolivia (de Wet *et al.*, 1983). Some species are widespread, but others have very restricted distributions (Appendix 5).

3. Networks

While there are numerous regional germplasm networks in the Americas, Africa, Asia, and Europe, most of the networks are more concerned with general information exchange rather than regeneration and active germplasm exchange. Most have budgets suitable only for holding occasional meetings and have had relatively little influence on active national or regional germplasm exchange, except for sometimes setting policies. The networks that have been most effective for maize are LAMP (Latin American Maize Project) and the Latin America Maize Regeneration Project. LAMP was funded in the mid-1980s with a US \$1.5 million contribution to the US Department of Agriculture (USDA) from Pioneer Hi-Bred International. Their CEO at that time was William L. Brown, who had been instrumental in collecting and studying the accessions of the races of maize in the 1950s and early 1960s. The regeneration project was initiated as a result of a unanimous recommendation of the National Plant Germplasm Resources Board of the USDA in 1983 (Brown was vice-chair). In many ways, the two

projects worked together. Over 12,000 Latin American accessions were evaluated through LAMP, sequentially identifying the more promising ones for further breeding work, and eventually identifying an elite set of about 300 accessions. An executive committee worked with a director to distribute funds to the collaborating national projects. This was probably the most extensive evaluation project ever carried out for a set of germplasm accessions. While it covered only 50% of the “available” accessions, it quickly demonstrated the sad status of the remaining 50%, for which there were not adequate viable seed to even have two replications at two locations. The regeneration project was coordinated at various times by North Carolina State University, Ft. Collins (then NSSL, now NCGRP), and CIMMYT. It eventually regenerated most of the maize accessions of Latin America, including those of LAMP, starting at a time when many were on the verge of loss due to limited funding and understaffing of national programs. The project director was responsible for the purchase and distribution of supplies and allotment of monies to the collaborating programs. This project has been quite successful, but a number of “difficult” accessions remain to be regenerated, while other accessions still need safety backup. Additional funding and some careful decisions on appropriate regeneration sites need to be made to complete this important project.

The LAMP project eventually led to the GEM (Germplasm Enhancement of Maize) project in the USA, a cooperative public/private endeavor to quickly expand the germplasm base of commercial maize. Elite germplasm accessions are crossed to private lines from US or foreign companies (or to public lines from foreign countries), families are derived by selfing, and top crosses are tested cooperatively to identify superior families. These superior families are first distributed to cooperators (US and international) and then, with a year's delay, to the general public anywhere in the world via the NCRPIS at Ames, Iowa. GEM is effectively governed by an elected Technical Steering Committee which oversees the efforts of the project directors at Ames and Raleigh; funding is through USDA-ARS and results from direct Congressional appropriations. GEM would be more effective with more international participation; at present there is little encouragement from the USDA (which has traditionally had a minimal interest in international collaboration) to do this. Together, these three projects represent much of the current leadership for protection, promotion, and utilization of maize germplasm resources.

4. Overview of ‘major’ collections

4.1 Germplasm Collections

The total number of unique New World maize germplasm accessions exceeds 27,000 (Tabata survey, 2006; see Appendices 6 and 7). Accession as used herein excludes inbred lines, synthetics, and other breeding materials and, unless otherwise noted, excludes teosinte and tripsacum). These accessions have been classified into some 300 races (Goodman and Brown, 1988). Major New World collections are listed in Table 1.

Table 1. Major New World Collections

Location	Size of own collection	Importance (9 = most important - 1= least important)	International seed distribution**	Duplicate stocks from elsewhere	Wild species stocks
Argentina	2,400	5	S-MTA		
Bolivia	1,500	8	N	23	1
Brazil	3,200	6	S-MTA	288	7
Chile	950	7	S-MTA		
Colombia*	1,800	7	N	1,800	
Ecuador	1,100	7	S-MTA	168	
Guatemala	900	8	N		
Mexico*	12,000	9	S-MTA	1,800	136
Paraguay	478	7	N		
Peru	3,000	7	S-MTA	37	
USA- NCGRP*	200	9	S	39,000	354
USA- NCRPIS*	1,300	8	Y	13,500	238
Uruguay	852	5	S		
Venezuela	1,200	6	N		
CIMMYT*	7,311	9	Y	17,632	308
TOTAL	38,191			74,248	1,044

* Hold regional or international accessions

** Y=Yes; N=No; S=Some; U=Uncertain MTA requires a Material Transfer Agreement

The relative importance of the various collections includes the uniqueness of their holdings, the expertise and historical documentation held by the banks and their collaborators, and the degree to which their holdings are available through the active international distribution centers (CIMMYT and NCRPIS). Historically, the original strains of maize in Latin America collected in 1950-60's with the National Research Council-Rockefeller collection missions were preserved in four national centers (Brazil, Colombia, Mexico, and Peru). Later (see Section 3), most were duplicated at CIMMYT and USDA germplasm banks.

Not all accessions have been classified by race, and not all can be classified. The latter include some that are mixtures of races; some that are descendants of hybrids; some that are mixtures of hybrids and races, or descendants of such mixtures. Documentation for some accessions requires improvement. Most New World accessions have been regenerated recently, most have duplicate preservation for safety, and most are available for distribution, either from CIMMYT or from the USDA's North Central Regional Plant Introduction Station at Ames, Iowa (NCRPIS), or from both. The number of Old World accessions is somewhat smaller (perhaps 20,000; based on Taba's survey; 40,000, if regional reports are included, but some of the latter may include breeding materials and accessions from other countries). More Old World accessions probably represent descendants of widely-distributed, open-pollinated varieties or hybrids, and sample duplication may be more of an issue with Old World accessions. Major Old World collections are listed in Table 2. Their regeneration status, safety backup status, and general availability are much less certain than for New World accessions. Actual availability of accessions governed by MTAs is uncertain. Past experience with seed requests to many of the germplasm banks requiring MTAs suggests that seeds might actually be available from less than half of them.

Table 2. Major Old World Collections

Location	Size of own collection	Importance (9 = most important - 1= least important)	International seed distribution**	Duplicate stocks from elsewhere
Angola*	600	2	U	
China	13,000	4	N	1,200
Ghana*	500	2	N	
India	1,300	3	S-MTA	
Indonesia	500	3	N	14
Japan*	6,000	2	U	
Kenya	1,100	3	S-MTA	
Korea, North*	7,000	1	N	
Korea, South*	7,000	1	U	
Morocco*	1,100	2	U	
Nepal*	500	4	U	
Pakistan	500	3	N	
Philippines*	2,000	4	U	
Romania	4,500	3	Y	800
Serbia	1,200	3	Y	4,600
South Africa*	900	3	S	
Sri Lanka	350	1	U	350
Turkey	1,500	4	S-MTA	
Nigeria (IITA)***	11	4	S-MTA	765
Total	42,061			

* From Regional Reports; may include accessions from other countries or breeding stocks

** Y=Yes; N=No; S=Some; U=Uncertain, MTA requires a Material Transfer Agreement

*** International

4.2 Genetic Stock Collections

In addition to the major germplasm collections, there is one primary maize bank specifically for genes, the Maize Genetic Cooperation Stock Center. The maize stock center has conserved and annotated the maize mutant stocks and made them available to maize geneticists worldwide for 74 years. It is located in the Department of Crop Sciences of the University of Illinois (123 Turner Hall, 1102 S. Goodwin Avenue Urbana, IL 61801-4798, USA). The center's expertise and service to the worldwide users of maize genetic stocks are well known. Approximately 85% of its core holdings currently have safety backup at NCGRP (Ft. Collins), but it also houses tens of thousands of "terminal" segregating families generated by recent multimillion dollar National Science Foundation (NSF) genomics grants as well. In addition, some of these same NSF grants are producing thousands of Recombinant Inbred (RI) populations that are really beyond the scope of the maize stock center's core mission, the study and preservation of stocks containing specific mutant alleles.

5. The importance - and the uniqueness – of the individual collections

The reasons for the differing rates among them are the extent of unique holding of the accessions or races of maize either from own country only or those including the adjacent countries. The original strains of maize in Latin America collected in 1950-60's with the National Research Council-Rockefeller collection missions were preserved in the four national centers. Later they were duplicated at CIMMYT and USDA gene banks.

The key collections are basically the international collections of the Americas, found at four sites:

1. CIMMYT
2. NCGRP (Ft. Collins)
3. NCRPIS (Ames)
4. Genetic Stock Center (Urbana)

CIMMYT houses most of the Latin American accessions, both for medium and long-term storage. There are low and high-elevation Bolivian accessions, intermediate and high elevation Guatemalan accessions, and some Caribbean accessions that are missing from CIMMYT's bank or lack regeneration. In addition, despite being THE world center for public maize breeding, for historical reasons, CIMMYT's germplasm bank has a very poor representation of public, tropical, inbred lines, and even lacks a few CIMMYT (CML) inbreds in its current inventory. Its representation of other important breeding materials is rather haphazard due to the long-term concept that the germplasm bank was for accessions, not breeding materials. However, the recent organizational reform of CIMMYT has streamlined integration of its maize breeding and maize genetic resources units. CIMMYT is widely regarded for its international collaboration and its willingness to share germplasm. Only recently has it even instituted shipping charges. It also now has a separate unit from the germplasm banks that handles shipping of both maize and wheat germplasm (the jury is still out on whether this is functioning well). CIMMYT houses many teosinte accessions, and it also monitors the existence of stands of wild and weedy teosintes, especially those in Mexico. The other three germplasm banks with large numbers of teosinte accessions are those of INIFAP (the Mexican national program), the University of Guadalajara, and NCGRP (FT. Collins). CIMMYT houses one of three major tripsacum gardens in the world; the others are at the USDA-ARS Subtropical Horticulture Research Station in Miami, Florida, and a USDA-ARS facility at Woodward, Oklahoma (see Appendix 5 for more detail about teosinte and tripsacum).

NCGRP (Ft. Collins) is the long-term storage center for the US, and it houses even more Latin American maize than does CIMMYT. It generally does not provide seeds directly, but works in conjunction with NCRPIS at Ames, IA, the medium-term storage facility and the regeneration branch for the USA. NCRPIS is renowned world-wide for promptly sending seed of its holdings postage-free to any location in the world that does not have extremely restrictive phytosanitary requirements. NCRPIS and NCGRP (Ft. Collins) hold many, perhaps most extant, public US inbreds, many breeding populations, and distribute patented and Plant Variety Protection (PVP) inbreds as their protection expires. NCRPIS is the first choice for most germplasm requests, as its holdings are extensive, its shipping is prompt and free, and there are no charges for the seeds. The major drawback is that there is a large backlog of materials that need regeneration and limited funding and facilities for regeneration.

The Genetic Stock Center at the University of Illinois is unique in the world. It houses virtually all of the mutants of maize, various chromosomal stocks, multiple mutant stocks, and various other stocks of interest to the maize genetics community. It provides these upon request to anyone, anywhere in the world, free of charge. It is short of space, but is currently expanding.

The national centers are important for various reasons. The most important are those of Brazil, Colombia, Mexico, and Peru. They were the original stock centers holding the NRC-Rockefeller collections of the 1940s-1960s, upon which the races of maize were defined and described. The national centers are not nearly as critical as the international centers for *ex-situ* seed storage, however. Almost all of the national New World germplasm banks have donated samples of their holdings to either CIMMYT or NCGRP (Ft. Collins), or both. What the national centers have to offer is their knowledge of, and experience with, their national accessions. For the most part, the Old World maize germplasm banks hold materials that are distinctly less

important than those of the New World. Most Old World materials represent maize of commerce, which represents only a small segment of the variation found in the Americas, perhaps 10% or less. The bulk of it represents US and Caribbean materials; the remainder is mostly low-elevation Mexican Tuxpeños and Brazilian/Argentine Catetos. These jointly account for about 10 of the 300 races of maize of the Americas. Perhaps the most unique Old World populations are the waxy maizes of South East Asia that are currently threatened by the expansion of hybrid maize.

What's missing from *all* of the germplasm banks are samples of important hybrids and private inbred lines (except recently expired PVP and patented ones which are available from NCRPIS).

6. Conservation status

6.1 Storage facilities, seed exchange and database management

The four major maize germplasm banks are well managed, with access to, and use of, appropriate medium and long-term facilities. Almost all Latin American accessions are stored at a minimum of two locations; many are stored at three. The storage conditions for all facilities surveyed are summarized in Appendix 8, and seed exchange and database policies are summarized in Appendix 9.

6.2 Sample sizes

Sample sizes are more than adequate at the 4 major locations, except the genetics stock center at Urbana, where sample sizes are deliberately small, to accommodate the large number of mutant stocks. The mutant stocks are virtually always homozygous, and cooperators know that they will usually receive few (often 15) kernels that they will need to increase themselves.

6.3 Regeneration status

Regeneration has proceeded well at CIMMYT, the accessions lacking regeneration there are usually "difficult" accessions, poorly adapted to the experimental facilities available. The status of regeneration at NCGRP (Ft. Collins)/NCRPIS is more problematic. The number of accessions is larger, the regeneration budget has been tighter, and the facilities (mostly on Puerto Rico and Saint Croix) more limited. In recent years, all regeneration has been conducted with a goal of 100 sib-mated ears per growout; that is probably an excessively high number, given the numbers of ears originally collected (usually 5 to 20, rarely more). In some cases it may be possible and efficient to combine regeneration efforts with *in-situ* conservation/farmer-assisted-breeding efforts.

6.4 Duplication status

Almost all accessions at CIMMYT are duplicated in national collections (although most national programs have very limited budgets and often have badly worn and outdated storage facilities); most have a long-term safety backup at NCGRP (Ft. Collins). Virtually all NCRPIS accessions have long-term backup at NCGRP (Ft. Collins). Most of the accessions at NCGRP (Ft. Collins) that are not at NCRPIS are backed up at CIMMYT, in fact that is where many of them came from. Many of these are also in the appropriate national collections.

6.5 Data available

Passport data are available for almost all maize germplasm bank accessions. However, there is little uniformity in its management. CIMMYT seems to prefer its own accession numbers; NCGRP (Ft. Collins) and NCRPIS use PI numbers almost exclusively; and only the national programs use the original accession numbers initiated with the remarkable National Research Council-Rockefeller studies upon which all the American Races of Maize bulletins were based. Evaluation data are available from both CIMMYT and NCRPIS. The quantity of data is fairly directly correlated with the year of last regeneration. Recently regenerated accessions tend to have more data. Many of the data are

descriptive and morphological. Only the US GRIN system is web-accessible, and it can be difficult to go from GRIN's PI numbers to original collection numbers.

National programs use either databases or spreadsheets of their own choosing (Appendix 9). There is little standardization, despite published international protocols. Many of the data collected beyond standard passport data consist of morphological data that are highly subject to genotype-by-environment interactions.

7. Collections that fail to meet accepted guidelines concerning conservation standards

Appendix 8 lists standards for both medium and long term storage for maize accessions. The national collections of Latin America are virtually all stored under medium-term conditions (a few have long-term storage), at approximately 5°C and 50% relative humidity (RH). The national banks have been underfunded, sometimes unfunded, for the past 50 years (this funding shortcoming basically began with the withdrawal of the Rockefeller Foundation support for such activities in the late 1950s and early 1960s). In the mid 1950s, virtually all Latin American maize was stored in three major germplasm banks: Brazil, Colombia, and Mexico. Once CIMMYT was functional, Brazil shipped its holdings (which included the collections from Argentina, Uruguay, eastern Bolivia, and the Guianas, as well as Brazil) to CIMMYT, and they formed the heart of the then newly-formed CIMMYT germplasm bank. Colombia initially held the collections for the Andean and northern regions of South America, from Chile to Venezuela. Peru took responsibility for its collections in the late 1950s, and since that time Colombia has slowly transferred most of the responsibility for the collections of other nations to either CIMMYT (Venezuela, Ecuador, and Bolivia) or the US germplasm system (Chile). As countries developed functional germplasm systems of their own, duplicate sets of the materials have been transferred back to the country-of-origin. The USDA Germplasm Regeneration Project and LAMP have led to renewal and backup of most accessions in recent years

The national collections of Africa, Asia, and Europe vary widely in size and scope, but virtually all are based upon the races of maize of commerce, which represent at most about 10% of the races of maize of the Americas. Thus, the materials housed in these banks represent secondary centers of diversity, but diversity of commercial maize that is often overlooked. Some of these banks – China and India, for example – are extremely well designed and managed; some are little more than refrigeration chambers, usually operated at about 5°C and 50% RH (unfortunately the tales of beef and more exotic fare being stored in seed cold rooms are sometimes true).

7.1 Development of core subsets

There is a real need to identify core subsets of the races, but this requires expertise not only in statistical procedures (of which there are many), but more critically, expertise on racial and accession classification and the availability of the type of data needed to develop reasonable classification decisions. There are few scientists with this sort of expertise and very little data that are really appropriate for the task (Sanchez *et al*, 1993). The races were originally defined largely on the basis of a combination of ecogeographical and morphological variation. Accessions typical of the races were chosen on the basis of field studies. These typical accessions have been used for most of the subsequent molecular marker work that has followed (*e.g.*, Sanchez *et al*, 2000; Matsuoka *et al*, 2002) and have basically served as core collections for more than 50 years. The need for core subsets rests on two anchors (1) the germplasm banks' needs to focus on specific accessions for regeneration, storage, and distribution; and (2) the users' needs for a rational sampling scheme to facilitate selection of materials to meet their objectives (Franco *et al*, 2006). While the typical accessions provide an initial, if perhaps slightly dated core, additional collections have been made since they were identified, and

molecular techniques have been developed, applied, and have finally started to become economically feasible. Development of core collections is critical, but they must be based on good phenotypic and ecogeographic data (where possible, GIS-based, consistent with the collection's passport data), as well as molecular data. Poorly developed sets of core collections can do real harm, not only by misleading potential users, but also by causing the neglect of important materials omitted from such cores.

7.2 Molecular data

While molecular data are useful, many of them are largely random with respect to meaningful interpretation. Experience has shown that a very large number of markers are needed. Even Liu *et al*, 2003, working with 94 micro-satellite (SSR) markers on a very diverse set of 260 inbred lines (which are much easier to classify than are panmictic populations) had problems grouping a few lines with their close relatives (by pedigree). Attempting to use even fewer markers with open-pollinated populations, as has occasionally been done, clearly will lead to even more errors in classification. While costs per datapoint have finally fallen, the current favorite, single-nucleotide polymorphism (SNP) markers, unlike SSRs, restriction fragment-length polymorphisms (RFLPs), or isozymes, often require a two-step procedure (i) grouping SNPs into haplotypes and (ii) using haplotype frequencies for grouping accessions or landraces. Molecular data represent just one piece of the relationship puzzle; genotype-by-environment interaction often rules trait-application expression or performance, and ultimately performance determines value for application. The most useful data for racial classification for both maize and teosinte are latitude, longitude, and altitude, if the 10 or so races of maize of commerce are excluded, and the same conclusion applies to many species of *tripsacum*.

7.3 Distribution of DNA samples

One area that has not been greatly explored by maize germplasm banks is the possibility of distributing DNA samples, rather than seed, to the growing number of molecular labs interested in germplasm. This would be particularly important when seed availability is low. Certainly this would be feasible for core collections, as the samples could be cheaply collected during regeneration or germination testing. Feasibility is, of course, dependent on required financial and human resources to collect and distribute DNA or tissues for DNA extraction relative to other priorities, such as regeneration. An efficient system for distribution of tissue or DNA is likely 10 to 100X less costly than the regeneration activities to produce seed and could satisfy a large segment of the research community. Distribution of DNA would not be subject to phytosanitary restrictions that sometimes impede germplasm exchange.

7.4 Germplasm management and breeding

The integration of breeding with germplasm management is much too broad an area to develop a complete plan here; however, there are segments that could and should readily be implemented. One example is the addition of materials with superior traits or research value, such as released inbred lines, significant breeding populations, and important commercial hybrids (or advanced generations thereof) to germplasm collections. With adequate safeguards of intellectual property rights, including required time-delays for public release of materials governed by PVP or plant patents, there is no obvious reason that private as well as public materials should not be included. In addition, collecting and providing basic data from germplasm increases (yield, standability, maturity, adaptation) would greatly increase the value of accessions to breeders and others interested in utilizing such materials. User-friendly, internet-access to such data, along with passport data, is long overdue and should encompass data held in all national and international collections.

7.5 Maize races in the regions

There is a need to extend the "Races of Maize" studies (summarized in Goodman and Brown, 1988) to other parts of the world. Such studies exist for Spain, India, Italy (Brandolini, 2006), and several East European countries. Limited studies exist for certain regions of the Himalayas and Japan. However, few studies like them exist for such maize-rich regions as China, Indonesia, and Turkey or for the entire

African continent. Notably absent is an equivalent study for the USA.

7.6 Regeneration vs. re-collection

There are a number of regions in the Americas where accessions have lain dormant in germplasm banks without regeneration due to lack of appropriate experimental facilities or lack of knowledge about where to grow "difficult" materials (Goodman, 1984). There have also been cases where regeneration was not possible due to limited funding for germplasm conservation, characterization and distribution. For example, several landrace accessions were collected in Ghana and Burkina Faso but largely lost due to the lack of adequate storage facilities and limited funding. In some cases, recollection of adequate samples makes more sense than regeneration, particularly for high-elevation landraces growing in areas unaffected by improvement programs (much of Oaxaca and Chiapas in Mexico, many Central American highlands, much of Andean Argentina, Bolivia, Chile, Ecuador, Colombia, and Peru). These are cases where national programs should have the knowledge and expertise to recollect. In other cases, appropriate environments for regeneration have been identified (for example, many Bolivian races and all the Amazonian races can be regenerated in winter nurseries in Florida), but have been under- or unused. In almost all cases, however, key accessions exist within these "difficult" sets that demand regeneration due to their historical importance (the typical accessions, for example). National programs should be able to assist with these efforts, some of which could readily be coordinated with farmer-assisted selection/*in-situ* conservation efforts. Much progress has been made on regeneration since the 1980s; many collections were regenerated in collaboration with CIMMYT in the 1990s. CIMMYT does not have duplicates of many national collections that North Carolina State helped regenerate in the 1980s. CIMMYT has received some 500 national accessions of Colombia from Ames, but many accessions from Bolivia as well as some from African countries remain to be regenerated for safety back-ups.

8. Distribution status

8.1 Availability of seedstocks

The availability of seedstocks of accessions of maize in the New World has changed from dismal (in 1980) to quite good today. Most accessions are stored in reasonable quantities (usually > 1 kg) in both national and international centers. The international centers (CIMMYT and NCRPIS) have functioning programs in place for phytosanitary inspections, packaging, and shipping. The situation for much of the Old World is much less clear, some countries (much of Europe, China, India, and Japan) appear to have adequate stocks and personnel, others may have large numbers of stocks, but quantity and availability are less clear (Appendix 9 has some relevant information).

8.2 Accessibility

The maize of the Americas is generally accessible through either CIMMYT or NCRPIS or both. Perhaps 10% of the accessions lack regeneration. The status of accessibility of Old World accessions is much more questionable.

8.3 Phytosanitary requirements

The limitations that current phytosanitary requirements place on germplasm exchange are often prohibitive, even for well-funded programs. For poorly funded programs, they form an immense barrier. Many of these limitations are of economic origin, designed to act as limiting or prohibiting tariffs to inhibit large-scale commerce (conceptually, at least, this is prohibited or at least limited by the SPS [Sanitary and Phytosanitary] Agreement of the WTO; Jensen, 2002). Examples: requiring freedom from southern leaf blight for seeds sent to countries where the disease is endemic (Argentina, South Africa, etc.) or limiting the percent of seeds with the common fungus *Fusarium* to 5% (Serbia). Many countries (including Mexico) restrict seeds containing any sign of Stewart's wilt, a minor disease of little real

pathological significance. Others require certification of freedom from diseases that do not occur in the regions where the seeds are produced (HPV [High Plains Virus] does not occur in Florida or North Carolina, yet seeds produced in those states sometimes require field inspections or laboratory testing to be shipped to some countries). Some countries require freedom from diseases that are highly unlikely to be seed transmitted (*Cercospora zea-maydis*, *Kabatiella zea*, and *Phyllostica maydis*, for example in maize; similar lists exist for soybean and other crops). Others simply greatly hinder or slow usage of materials, for example Australia and Brazil require that all new genetic materials must pass through a post-entry quarantine process with few seeds that require several subsequent increases before any real experimentation can take place. There are legitimate reasons to screen maize seeds from certain areas where important seed-borne diseases occur, but these are often the exception. In many cases, boatloads of maize enter a country more freely than a packet of 50 insect-free kernels of an important germplasm accession. These problems are severe, and they are not restricted to maize, either in their severity or their inappropriateness. Current concerns over the presence of GMOs and related import restrictions simply add to already-existing problems.

8.4 Past experience

Both CIMMYT and NCRPIS ship several hundred kernels of an accession to most locations in the world within a few days or weeks (unless unreasonable phytosanitary restrictions exist in the recipient country – see above). To some degree, the general ineffectiveness of national maize germplasm banks in international seed distribution can be attributed to minimal budgets combined with unreasonable phytosanitary requirements restricting seed distribution. Almost none exchange seed freely, although bank to bank interchange is not unusual. Some are better than others at responding to individual international requests. Some of the reasons for the failure to freely participate in international seed exchange are budgetary. However, some of the reasons are political and bureaucratic, occasionally based on overestimates of the potential commercial value of germplasm. Fears associated with patenting genes or germplasm have tended to paralyze seed interchange in recent years. Still, the distribution efforts and policies of the NCRPIS at Ames, Iowa, USA, stand in stark contrast to those of all other national New World maize germplasm banks. Only the maize germplasm bank at CIMMYT compares well with the efforts made at Ames, a bank that has often had severe budget limitations (although rarely as limited as most Latin American national banks). Unless these problems, which are sometimes political, sometimes legal, occasionally nationalistic, and almost always budgetary, can be met head-on, the role of national germplasm banks in global efforts will be severely constrained. The resulting loss of genetic diversity and capacity in the form of expertise and research networks will be felt internationally and will be irreversible. As there has been less interest in Old World accessions, there is little past experience with which to judge actual availability.

9. Analysis of which collection holders are unable to readily make material available internationally

In Latin America, Argentina, Chile, Paraguay, Uruguay, and Colombia lack funding for international exchange. Bolivia, Ecuador, Peru, Venezuela, Guatemala, and Mexico lack funding and also have legal restrictions.

In the Old World, there are funding restrictions, political restrictions, and phytosanitary restrictions for much of Africa and Asia. China has political restrictions, while the situations with India, Japan, and South Korea are currently uncertain (see Table 2).

10. Synthesis of conservation and distribution

The collections of CIMMYT and the combination of NCRPIS (Ames)/NCGRP (Ft. Collins) generally meet expected international standards for maintenance and distribution. Both do have backlogs for regeneration; CIMMYT's are smaller, but perhaps more troubling, as their backlogs represent difficult ecologies for which regeneration policies have yet to be established. The genetic stocks of the Maize Cooperation Stock Center at the University of Illinois also generally meet such standards, except for lack of on-site, long-term storage. Like NCRPIS, the Urbana center relies upon NCGRP (Ft. Collins) for long term storage, but about 15% of their stocks lack such a backup.

11. Major collections not meeting standards

11.1 Extent to which the diversity within the collection is, or is not, already represented within a collection that meets the standards for conservation and distribution

For the New World, virtually all the diversity housed in the national centers, which generally fail to meet international standards (for lack of long term storage, lack of resources for meeting international seed requests, and/or legal limitations on seed shipments), is found at CIMMYT and NCRPIS (Ames) / NCGRP (Ft. Collins). The accessions housed in the national collections of the Old World are another story altogether. Few of these are backed up at the international centers; many are essentially unavailable to non-national (and sometimes even to national) users; and assurance of periodic regeneration is often uncertain. The loose-knit European maize network (Lipman, *et al.*, 1997) is one exception to this, but even there long-term storage and secure backup seem not to be well-defined.

11.2 Importance of any diversity not already represented

There are a few areas where adequate collections were never made (portions of the Amazon basin, parts of Central America, waxy maize in SE Asia). The original collections from the island of Dominica (*not* the Dominican Republic) were completely lost. While France has sampled the maize germplasm from the French Caribbean islands and deposited it in their germplasm collections, no samples have been deposited in the international banks and no published studies of the sampled variation exist. The original collections from Dominica included the typical collections of the important commercial race, Coastal Tropical Flint. Many of the collections sponsored by IBPGR in the 1970s were lost, as there was not an effective germplasm maintenance program active at that time, at CIMMYT or elsewhere. Neither public nor private tropical inbred lines are well represented, nor are important hybrids (or their bulk increases).

11.3 Specific requirements for collections to be able to meet the standards for conservation and distribution

This information is simply not readily available for many national collections. It is often possible to determine the nominal conditions for seed storage, but if backup generators are not available, not fueled, or not maintained, the end result is many packages of non- or poorly-germinating seed. Simply signing agreements and treaties does not guarantee seed distribution. The restrictions may simply be monetary, but the more severe ones are political/legal. One could send out surveys asking about these points, but there are often limits on what technical staff may say (and such restrictions are not limited to under-developed countries). Even visiting the germplasm bank sites might not be sufficient, although it would greatly increase our present knowledge.

12. Identify any other collection that was not included among the original set of 'major' collections but that nevertheless has important genetic diversity

The Vavilov Center in St. Petersburg (Russia) once held worldwide accessions of maize. The many years of restricted budgets, poor or non-existent facilities for regeneration, and deteriorating facilities appear to have greatly reduced the integrity of these collections. There may still be important accessions held at the National Seed Storage in Kuban, near the city of Krasnodar. This would require further investigation to verify.

13. Potential improvements for collections that meet standards

13.1 Specific actions that could be undertaken in the short term to increase the efficiency and effectiveness of conservation collectively

CIMMYT needs support to finish up the Latin American Maize Regeneration Project at a rate of about US \$ 300,000/year, for a period of 5 years. CIMMYT may be able to raise some of this money itself, but given the misery that currently hovers over all the international centers, it probably cannot raise more than half. If outside funds are not available, this project may well cease.

NCGRP (Ft. Collins) is in the same boat with NCRPIS, both need funds for a backlog of regeneration needs. Those needs are in the US\$ 250,000/year range for the indefinite future, certainly 10 years or more. In addition, NCRPIS is the likely site for initiating the metadatabase for maize. They currently provide the only web-accessible database, the often maligned GRIN system, which more or less works, but not in a user-friendly way. The initial costs for that would be fairly high, at least US\$ 250,000/year for 2 years, and US\$125,000/year for 2 more years to clean things up. While the US germplasm system might match half or more of the regeneration costs, they would be unwilling to foot very much of the costs for an international database network, perhaps at most 15 to 20% of the overall costs. If outside funds are not forthcoming, the regeneration will proceed at a very slow rate; the metadatabase for maize will not happen.

The Genetic Stock Center's major needs are additional cold storage space at perhaps US\$ 100,000 (particularly if they are to house the increasing number of recombinant inbred populations) and added technical support at US \$60,000/year. This center probably has enough political clout to raise most of these monies from USDA sources (they have recently received a modest increase in cold storage space). US\$ 10,000 to 20,000 of seed money might raise it much sooner.

13.2 A process to be followed for identifying other potential areas of need or improved efficiency

A small international committee (or indeed a single person) needs to solicit suggestions for maize germplasm banks worth visiting, then visit them (or have a proxy visit) and report on what needs to be done next. Clearly, there is a need for CIMMYT and INIFAP to collaborate more directly on the 10,000+ Mexican accessions. CIMMYT and NCRPIS could collaborate on germplasm regeneration. National programs could be tapped for more regeneration and more information on the accessions. Until a metadatabase for maize is placed in operation, many of the needs and much of the duplication will go unrecognized.

13.3 Ways in which cooperation per se might be enhanced, e.g. through a strengthening a specific crop or other network.

The Latin American Regeneration Project and the LAMP Project should both be extended to other important collections; the LAMP project covered only about 50% of the potentially available Latin American accessions. The maize metadatabase and the international committee should be able to pinpoint such collections. This cost may be about US\$ 2 million. The GEM project should be extended to include additional international collaborators at a cost of US\$ 500,000 annually for a period of 15 to 20 years; the USA might cover a substantial portion of this, perhaps 50%, but would be unlikely to shoulder the entire burden.

14. PLAN OF ACTION

14.1 Global Accessions Management: Identifiers, Essential Metadata, and Standardization

The most reasonable starting point is to develop a plan for generating downloadable information lists of all consequential maize germplasm bank holdings available over the internet. A comprehensive, easily-used, metadatabase *solely for maize* germplasm is needed that could retrieve base data from individual maize germplasm banks (which may each have different types of lists and different, perfectly functional, software programs). Users must have the ability to download Excel-compatible spreadsheets on sets of accessions circumscribed by geographical origin, race, germplasm type (accession, breeding stock, population, inbred, etc.), core membership (where available), seed availability, and safety backup information. Most existing databases are sound, but even the most accessible of them are not user-friendly, even for knowledgeable users. Minimum data needed would be passport data, but much more would be feasible, including digital photographs. This should be done in collaboration with MaizeGDB (<http://www.maizegdb.org/>), which already lists inbred lines held in the US germplasm system, and possibly with Gramene. CIMMYT and IRRI are collaborating to develop a germplasm bank management system, and that needs to be coordinated with other maize genetic resource efforts. For the past few years, efforts have been made within the CGIAR centers to establish a system-wide information network for genetic resources (SINGER). This global information system is accessible via the internet (<http://singer.grinfo.net/>) and is aimed at implementing a one-stop entry point for information on, and access to, the in-trust collections of the CGIAR centers. At this point, SINGER is even less user-friendly than GRIN. The challenges in using information compiled from various database sources are significant. The most pressing problem is to resolve the various acronyms and numbering systems used for the same accessions (e.g., Chs30 = CHS 30 = CHIS 30 = Chiapas 30 = CHIAPAS 0030, a simple example), and allow a user to access the material using *any* of these (or other reasonable) codes. (For a challenge, try standardizing the collections of Guatemala or Peru or those of the states of Chihuahua or Oaxaca on the CIMMYT database on the CD of the 2006 Maize Germplasm Network Meeting; the NPGS database provided has no real collection names to standardize). Inclusion of digital photos of at least ears and kernels with the passport and field data is critical. Potential users need to know, at a minimum, information on adaptation, relative maturity, plant height, and susceptibility to lodging in order to select materials that can be successfully grown and utilized. Evaluation data - agronomic, phenotypic or biochemical - need to be end-user, trait-oriented, while being aware that (unlike self-pollinated crops) the variation within accessions is often as large as the variation among accessions within a specific region. Resolving these issues needs to involve not only current expertise of both germplasm and database authorities, but the education of a new generation of maize germplasm specialists. Funds are needed immediately to provide resources and expertise to resolve the differences among identifiers of the accessions between various maize databases and to standardize the identifiers; *a maize database Swat Team is needed NOW*. It must be recognized that accessions with common identifiers but different seed sources may not be exactly (and, occasionally, not even approximately) identical. The CIMMYT maize bank has placed CIMMYT ID numbers on accessions of in-trust collections received from cooperators. The cooperator banks' identifiers of the accessions are registered as associated identifiers. NCGRP (Ft. Collins) has used CIMMYT ID numbers for its inventory in the safety back up collection. This type of labeling system is widespread; the PI numbers in the US follow the same pattern. While CIMMYT ID numbers or US PI numbers are very helpful to curators and other insiders, virtually all outside researchers use the original accession numbers. Neither a CIMMYT ID nor a US PI number has much meaning to users outside their respective systems. While GRIN can be (sometimes) used on line to decipher a PI number, there is currently no web access to CIMMYT ID numbers. As an example of the iterations one can encounter, consider Lim 13, a well-known Peruvian accession. It has been assigned at least five identifiers over the past 50 years. First, the Colombian bank assigned it a PER number; then the NAS-NRC assigned it a NRC number; then Peru assigned it "Lim 13," then the USDA assigned it a PI number, and, finally, CIMMYT assigned it a CIMMYT ID number. Along the way, it is quite possible that EMBRAPA assigned

it a Brazilian number, and it may have acquired Chinese, Russian, and Yugoslavian numbers as well. And of course we have not considered the various iterations of Lim, LIM, Lima, and LIMA or 0013, 013, 13, 13, etc. Thus, a single accession can acquire a plethora of labels, many of which would be meaningless even to the authors of *The Races of Maize in Peru*.

14.2 Global and Regional Cooperative Networks and Availability of Seed Accessions

The next priority would be:

- (1) to use the maize database, in conjunction with national germplasm bank expertise, to determine which accessions exist but for which viable seeds are NOT available for current distribution
- (2) to determine which ecogeographic areas are under- or unrepresented in the collections and in need of collection or re-collection, and
- (3) to establish which existing accessions are most in need of immediate regeneration (based on age and quantity of seed, significance of the accession, etc.).

Identification of needs must be followed by prioritization and by immediate action to remedy the problems identified. Resources are critically needed for the recollection of rare, endangered, and non-adapted races, including those landraces that are soon to be replaced by improved maize. Collecting broader-based samples than was done originally would be helpful. The current goal is to obtain regenerations of 100 sib-pollinated ears each from accessions that most often were originally collected as five to ten open-pollinated ears. Thus, most often, the initial effective population size was less than 20; at least a few were based on single ears and some were collected as bulk seed at local markets. While recollecting, collection of indigenous knowledge must be a priority (particularly for utilization and cultural uses), and agronomic and phenotypic evaluation data need to be collected during regeneration. These are excellent opportunities for training the next generation of specialists and for international collaboration.

One potential strategy suggested for enhancing regional collaboration in sub-Saharan Africa is through the establishment/strengthening of a regional network of maize germplasm conservation. The network needs to bring together germplasm conservation specialists from the various National Agricultural Research Systems (NARS) to design appropriate strategies for germplasm collection, conservation and distribution. This network could facilitate the development of collaborative projects for germplasm collection, evaluation, distribution, and information exchange. The network could request that scientists in the NARS from different countries in Africa that need to carry out critical maize germplasm collection expeditions develop project proposals and submit them for funding. Panels could be formed to review proposals and approve those that are well conceived. As a requirement for conducting the collaborative project, the network could insure sharing of the collected germplasm with CIMMYT, IITA, and/or NCGRP for long-term storage. Similar plans might work elsewhere.

14.3 Global and Regional Ex-situ Conservation Network: Regeneration and Safety Backup

Safety backup for all accessions should be possible once a comprehensive maize metadatabase is operational. All maize accessions should be backed up for long term storage at NCGRP (Ft. Collins) and at CIMMYT in quantities of at least 1 kg each at each location. Typical accessions and/or core accessions should have 3 kg each. It is far more expensive to regenerate an accession multiple times than to do it right the first time. Current medium term storage conditions (+5° C, 25% RH) easily allow for 20 years storage. At the current distribution rate of the US NPGS, almost 40% of the collection (sans cores) needs regeneration every 10 years. Current long-term storage (-20° C) requires regeneration at intervals of over 100 years (exact statements are not possible, but excellent germination has persisted for well over 50 years). Safety backup is particularly critical for non-New-World accessions; Asian and African accessions appear particularly vulnerable to loss. Even those countries for which routine seed exchange is impossible for political or phytosanitary reasons must make provision for safety backups.

In addition, core subsets of maize germplasm should be sent to Svalbard, the international high security seed-vault now under construction in Norway, provided that its temperature and relative humidity conditions meet standards for long term storage of maize.

14.4 Collaboration on Maize Germplasm Conservation and Capacity Building of Maize Germplasm Specialists

The roles of national versus international germplasm banks must be clarified; each type of germplasm bank needs to determine its role in a global germplasm system and focus its resources and activities accordingly. National germplasm banks that are inactive in terms of fulfilling individual seed requests may have other, equally important, roles to play in terms of germplasm collection, regeneration, maintenance, education, and knowledge. Those maize germplasm banks actively filling international seed requests appear to be largely limited to NCRPIS and CIMMYT at present. While IITA serves as a regional maize germplasm bank for much of Africa, quarantine restrictions (fear of spreading *Striga*, downy mildew or maize streak are at least some of the causes) limit its role on the wider international stage. IITA's active involvement in the Phytosanitary Council and the establishment of seed regulatory mechanisms should facilitate the distribution of maize germplasm accessions from its bank across countries in sub-Saharan Africa. IITA needs to assess and coordinate maize germplasm collection in West and Central African and cooperate with other germplasm banks in East and South African regional efforts. CIMMYT is willing to provide safety backup for all African accessions and is willing to house, maintain, and distribute core collections, once these are identified, and important breeding stocks, including released African inbred lines. CIMMYT and the NCRPIS (Ames) will remain the main distributors of seeds of germplasm accessions, with CIMMYT and NCGRP (Ft. Collins) sharing long-term storage. For the most part, national programs need to concentrate on local maintenance, education, and within-country distribution and utilization. National collections are important; each country has an obligation to provide its people with their own genetic resources. The contributions of national germplasm banks toward understanding the nature of the accessions, their current and historic uses, particularly for human food, and toward educating the next generation of curators are essential. National banks can also identify those areas that have never had good collections, where it is still possible to do reasonable collecting. For an international system to function, there simply must be cooperative use of resources - for documentation, regeneration, data collection, and preservation of accession history and uses. No single institution can do everything. Germplasm bank managers and curators are the resource experts for users, and a web-based, maize database will greatly help users, but will generate still more questions and requests for information from the national banks, even with seed shipments being handled globally or continentally.

14.4 Germplasm conservation and management need to be integrated to improve agricultural productivity

While increased maize production is one goal of genetic resources programs, enhancing food security, reducing poverty and protecting the environment are at least equally important goals, particularly in Sub-Saharan Africa and in Indigenous areas of the Americas. Strategic evaluation of maize germplasm accessions combined with genetic enhancement will be important to achieve this. Maize germplasm accessions must be evaluated systematically in order to search for desirable traits needed in the prevailing production systems, identify sources of resistance to diseases, pests and parasitic plants, as well as to locate sources of tolerance to abiotic stresses. Novel traits identified from the results of evaluations will be invaluable raw materials for supporting genetic enhancement for increasing productivity. The lack of extensive genetic enhancement research activities is considered to be one of the major factors limiting the use of landrace collections maintained in germplasm banks. This is particularly true for maize breeders in sub-Saharan Africa and elsewhere, who face substantial pressure to generate improved varieties adapted for their particular countries with limited resources and thus cannot afford to invest these resources in long-term genetic enhancement projects. Genetic

enhancement will be carried out at IITA to transfer the required traits into suitable genetic backgrounds that can be distributed as breeding materials for use by NARS in Sub-Saharan Africa and elsewhere for their maize breeding programs.

14.5 Improved Access to Conserved Germplasm

To address the phytosanitary restrictions on germplasm quantities of seed, a united front with other crops will probably be necessary. The use of seed quarantines solely to limit commerce is indefensible; the impositions of phytosanitary rules that are in conflict with common sense is self-defeating and not in a country's own best interests.

14.6 Conservation of Wild Relatives of Maize: Teosinte and *Tripsacum*

Seed collections of the teosintes need to be safely duplicated at NCGRP and CIMMYT. National/International Reserves need to be established to protect the remaining fragments of the Balsas, Guatemala, Huehuetenango, and Nicaraguan races of teosinte. International collaboration of teosinte experts from the Colegio de Postgraduados, ICTA (Guatemala), INIFAP, the University of Guadalajara, the University of Massachusetts, and the USDA-ARS is vital (see Appendix 5). CIMMYT's current *ex-situ* tripsacum garden at Tlaltizapan, Morelos, should continue to be maintained, with a duplicate garden established in Veracruz (or some equivalent lowland, tropical environment). Seed samples collected from the clones should be conserved in the bank and made available for requests. Another tripsacum garden could be established near IITA headquarters in Africa. IITA has experience in utilizing teosinte, and thus can exploit the available wealth of diversity in both teosinte and tripsacum for genetic enhancement of maize germplasm in different parts of Africa. *In-situ* monitoring of tripsacum populations should be conducted in Mexico and Guatemala, the center of diversity for the genus, and in other countries in Central and South America, where both widespread and endemic species are found. *Ex-situ* tripsacum gardens at CIMMYT and USDA in Florida should be enriched with the diversity found in *in-situ*, and more collaboration should occur between these two unique sites. Unless there is some mechanism to establish who is responsible for the wild relatives of maize, they will continue to fall through the cracks. The most reasonable solution to this problem is to place the responsibility for teosinte and tripsacum conservation with the maize germplasm banks. Until now, collection – and much of the maintenance – of teosinte and tripsacum has been conducted by botanists and geneticists who do not have proper facilities or budgets for such long-term endeavors.

15. Conclusions and consequences

The major conclusions are that for maize there are really three major international-level collections: (1) CIMMYT (Texcoco, Mexico), (2) NCRPIS (Ames, USA)/NCGRP (Ft. Collins, USA), (3) Maize Cooperative Genetic Stock Center (Urbana, USA). The national collections are primarily – and vitally - important as knowledge and training bases. The collections of the Americas are generally of much greater consequence than the accessions from the Old World.

There is a need for financial support of a metadatabase for maize germplasm that is user-friendly and web-accessible, and there is still a need for support of regeneration (or re-collection where it is more efficient and effective than regeneration) in critical regions.

There is a serious need to train a new generation of maize germplasm specialists, and that training should include experience at the national centers with the new maize metadatabase. A small, forceful international committee needs to examine the needs of the entire maize germplasm community and be willing to fight to make it more effective and more responsible.

15.1 Access to improved material and crop improvement

The application of projects such as GEM (Germplasm Enhancement of Maize) and CIMMYT's germplasm enhancement efforts would certainly be assisted by having basic agronomic data available for accessions. These and similar germplasm enhancement-type projects would also be greatly aided by having ready access to released international inbreds and elite breeding populations. Various

molecular association studies and most disease- and insect-screening trials for molecular or field studies would also greatly benefit from ready access to such materials.

While IITA has made some efforts to utilize landrace accessions for combating downy mildew, maize streak virus, *Striga hermonthica*, southern corn rust and stem borers, the number of accessions used has been very limited. Furthermore, most studies of races, pests, or pathogens have not included a broad spectrum of African or Asian materials, as they have simply been generally unavailable. Comprehensive racial studies of such materials would allow systematic sampling, and safety backups of such materials are imperative. Regional interchange among China, India, Indonesia, the Koreas, Japan, and the Philippines would accomplish a minimal safety backup network for East Asia, although current political realities may present insurmountable temporary barriers to some of this.

15.2 Safety duplication

China, India, and Japan are certainly capable of doing their own collecting, conservation, and maintenance, but safety maintenance and seed availability on an international level are concerns. For example, seed of Southeast Asian waxy germplasm is not held by any of the international germplasm banks. Core collections and important breeding materials need to be sent to CIMMYT or NCGRP (Ft. Collins), depending upon the ease of exchange and latitude of the accession. CIMMYT is willing to maintain and distribute the core collections (including inbreds and important breeding materials) of Southern China and other tropical and semitropical countries of the region.

IITA can serve as coordinator for Africa, facilitating germplasm transfer. It should also house the African core collections and advanced breeding materials, which should be shared with CIMMYT. Regional exchange among Turkey and the countries of East Europe would accomplish safety backups for these important accessions, and such materials would most appropriately be housed at NCGRP (Ft. Collins) for permanent protection. Such activities would obviously need to involve the Ministries of Agriculture and, where appropriate, the Agricultural Science Academies. European accessions from both eastern and western Europe need to be incorporated into a unified network, and their accessions need to be permanently stored at NCGRP (Ft. Collins) or some other suitable site, with safety backups in more than one European country. At present, only NCGRP (Ft. Collins) appears to be willing to accept maintenance of all Old World accessions. The database efforts of SINGER, Zemun Polje, and other European systems (Lipman *et al.*, 1997) need to be incorporated into a worldwide web-friendly, metadatabase for maize germplasm. Certainly other options for the backup storage sites, such as the nearly-operational germplasm bank at Svalbard, Norway, will emerge and should be considered in terms of duration of seed viability, institutional policies, shipment costs, and access possibilities.

15.3 Filling gaps in collections

With a relatively small amount of intelligent re-collection and a stronger focus on the most important "difficult" accessions, the ecogeographic sampling for maize in the New World will be essentially complete. It is extremely important to act now, as economic and demographic changes are eroding the genetic diversity of maize in many areas that were once untouched by modern agricultural, horticultural, forestry, and industrial practices. Perhaps the greatest problems to be overcome are the various barriers to seed exchange ranging from phytosanitary infelicities to political embargoes. The Global Public Good Project, a World Bank-funded project aimed at improving the operations of CGIAR germplasm banks, may help in optimizing the maize global strategy.

15.4 Training in maize genetic resources

Along with the will to provide resources for the regeneration of accessions non-adapted to the ecology of the germplasm banks, and the resources to recollect material, we need to address the depth of expertise in maize genetic resources. It is important to rapidly identify suitable candidates for training in

the field of maize conservation and use in the next five years. At least twelve young scientists need to be employed globally in this area within the next 10 years; more would be much better. This training should be in conjunction with both national germplasm resources programs and with allied breeding programs in order to facilitate collaboration between the two. Experience with *in-situ* conservation efforts would also be desirable. There is an obligation of each nation to train its own essential personnel, but germplasm expertise has international value as well. The training of future maize genetic resource experts, breeders, entomologists, pathologists, and agronomists capable of focusing on the practical aspects of agricultural production challenges is critical. Without these people, most of the potential to apply the genetic discoveries and technologies resulting from use of plant genetic resources will be lost.

15.5 Maize wild relatives

Opportunities for contributions from the wild relatives of maize to maize breeding challenges may increase in the future as current molecular breeding technologies advance. Social and environmental changes threaten stability of long-term conservation *in-situ*, and necessitate *ex-situ* backup. Evolutionary bottlenecks from teosinte to maize and from indigenous maize to commercial maize have occurred. The genetic diversity of teosinte and tripsacum is relevant to maize research and breeding efforts for maize productivity, nutritional quality, bio-energy production, and other uses.

15.6 Global maize genetic resources registry

The time for holding additional maize germplasm meetings and for writing extensive papers on the woeful status of the maize germplasm system has long past. Had as much effort gone into developing a user-friendly database for maize germplasm as has gone into organizing meetings about the status of maize germplasm, we would be able to Google "Lim 13" or "Chs 30" and acquire useful information about their racial assignments, agronomic characteristics, and seed availability in a matter of seconds. Much effort toward maize germplasm conservation and utilization has been made over the past 20 years, but many of the fruits of those efforts will remain elusive until a user-friendly maize database is deployed.

LITERATURE CITED

1. Anderson, E. 1944. Cytological observations on *Tripsacum dactyloides*. Ann. Mo. Bot. Gard. 31: 317–323.
Brandolini, D. A. and A. Brandolini. 2006. Il mais in Italia: storia naturale e agricola.
2. de Wet JMJ, Brink DE, and Cohen CE. 1983. Systematics of *Tripsacum* section, Fasciculata (Gramineae). Amer. J. Bot. 70:1139-1146.
3. Franco, J., J. Crossa, M.L. Warburton, and S. Taba. 2006. Sampling strategies for conserving maize diversity when forming core subsets using genetic markers, Crop Sci. 46:854-864
4. Goodman, M. M. 1984. An evaluation and critique of current germplasm programs. Pp. 195-249 in 1983 Plant Breeding Research Forum Report. Pioneer Hi-Bred International, Des Moines, Iowa.
5. Goodman, M. M. and W. L. Brown. 1988. Races of corn. Pp. 33-79 in G. F. Sprague and J. W. Dudley (Eds.), Corn and Corn Improvement--Agronomy Monograph No. 18. Agronomy Society of America. Madison, Wisconsin.
6. Jensen, M.F. 2002. Reviewing the SPS Agreement: A Developing Country Perspective. Danish Research Institute of Food Economics, Working Paper No. 1/2002.
(www.foi.kvl.dk/upload/foi/docs/publikationer/working%20papers/2002/1.pdf).
7. Lipman, E, R.H. Ellis, and T. Gass (compilers). 1997. Maize genetic resources in Europe. Report of a workshop, 28-29 May, 1996, Rome, Italy. IPGRI, Rome.
8. Liu, K., M. M. Goodman, S. Muse, J. S. C. Smith, E. S. Buckler, and J. Doebley. 2003. Genetic structure and diversity among maize Inbred lines as inferred from DNA microsatellites. Genetics 165: 2117-2128.
9. Matsuoka, Y., S. E. Mitchell, S. Kresovich, M. Goodman and J. Doebley. 2002. Microsatellites in *Zea* - variability, patterns of mutations, and use for evolutionary studies. Theor. Appl. Genet. 104:436-450.
10. Sanchez G., J. M., M. M. Goodman, and J. O. Rawlings. 1993. Appropriate characters for racial classification in maize. Econ. Bot. 47:44-59.
11. Sanchez G., J.J., M.M. Goodman, and C.W. Stuber. 2000. Isozymatic and morphological diversity in the races of maize of Mexico. Economic Botany. 54:43-59.
12. Sluyter, A. and G. Dominguez. 2006. Early maize (*Zea mays* L.) cultivation in Mexico: Dating sedimentary pollen records and its implications. PNAS 103:1147-1151.
13. Taba, S. 2005. Latin American Maize Germplasm Conservation: Regeneration, In situ Conservation, Core Subsets, and Prebreeding. CIMMYT, Mexico City.
14. USDA-ARS. 2005. Races of Maize Collection. CD compilation. Ames, IA
15. Wilkes, H. G. 1967. Teosinte: the closest relative of maize. Bussey Inst., Harvard Univ., Cambridge.
16. Wilkes, G. 2004. Corn, strange and marvelous: But is a definitive origin known? Pp.3-63 in Smith, C.W., J. Betrán, E.C.A. Runge (eds.), Corn. Origin, History, and Production. John Wiley, Hoboken, N.J.

Appendices

APPENDIX 1: Survey of the maize collection information in Maize Crop Strategy Development

A. Questionnaire on organizational information and legal status of the maize collection:

1. 1. Organizational information

Name and address of organization holding/maintaining the (crop name) collection	
Address:	
City:	
Postal code:	
Country:	
Web site:	
Curator in charge of the (crop name) collection	
Name:	
Address:	
City:	
Telephone:	
Fax:	
Email:	
Name of respondent to this questionnaire, if different than above	
Contact details:	
Date of response:	

1.2 Additional key contact persons for the above germplasm collections

Name	Title/Function	Email address

1.3 Please describe the organization

- Governmental organization
- University
- Private organization
- Other: please describe: _____

1.4 Is the institution in charge of the (crop name) collection the legal owner of the collection?

Yes No

If no, who is the owner (including no owner identified)? _____

1.5 Is the collection subject to the terms and conditions of the International Treaty on Plant Genetic Resources for Food and Agriculture?

Yes No

If no, please indicate if it is expected that the collection will come under the International Treaty, and if so when
If it is not expected to come under the International Treaty, please indicate whether or not the material is available for international distribution, and if so under what terms and conditions

**B. Questionnaire for the maize collection manager for the global maize crop strategy
coordinated by CIMMYT**

Table 1. Unique characteristics of the maize collection

Institution name:
Country:
Collection manager name:
Email:

Accession category	Country of origin	No. of accessions	No. of introductions ¹	
			Own country	Other countries
Landrace accessions				
Own country .-				
Other country 1.-				
Other country 2.-				
Other country n.-				
Improved populations/synthetics				
Own country .-				
Other country 1.-				
Other country 2.-				
Other country n.-				
Open pollinated varieties				
Own country .-				
Other country 1.-				
Other country 2.-				
Other country n.-				
Inbreds				
Own country .-				
Other country 1.-				
Other country 2.-				
Other country n.-				
Teosintes				
Own country .-				
Other country 1.-				
Other country 2.-				
Other country n.-				
Tripsacum				
Own country .-				
Other country 1.-				
Other country 2.-				
Other country n.-				

1. Accessions that are included in the collection from own country or other countries.

**C. Questionnaire for the maize collection manager for the global maize crop strategy
coordinated by CIMMYT**

Table 2. Seed storage conditions

Institution name: 0
 Country: 0
 Collection manager name: 0
 Email: 0

Seed storage category	Storage temp. (°C)	Storage humidity (%RH)	Type of container ¹	Initial storage quantity ²	Seed viability (%)	Storage size (m ³)
Long- term collection (30+ years)						
Medium-term collection (until 30 years)						
Short-term collection (until 10 years)						

¹ Please describe if aluminum laminate or other types of bags are used.

² Initial number of seeds or initial seed weight when the accession is deposited.

**D. Questionnaire for the maize collection manager for the global maize crop strategy
coordinated by CIMMYT**

Table 3. Seed exchange policy and use of information databases

Institution name: 0
 Country: 0
 Collection manager name: 0
 Email: 0

Seed exchange function	Handling seed requests/shipments	Seed inventory/paperwork
An accession database	Used () Not used ()	Updated () Not updated ()
Who authorizes the shipment?	Collection manager () Other* ():	
Name 1 and title:		
Name 2 and title:		
Are accessions duplicated elsewhere	Yes ³ () No () If yes, where:	
Seed shipment	Seed accessions available() Not available ()	
- No. of landrace accessions for which seed are available upon request	No.:	
- Seed quantity available for a single routine request	Number or weight (g):	
- Cost of seed	Free () Charge ()	
- Cost of shipment	Free () Charge ()	
MTA¹ used/required	Used () Not used ()	MLS ² () Bilateral () Other () specify:

* Please, specify who authorizes the shipments and what position(s) he/she/they hold.

¹ Material Transfer Agreement.

² Multilateral System of Seed Exchange.

³ Please, specify where the duplicates are sent.

APPENDIX 2: List of collection managers contacted through a survey

	Country	Full Name	Institute's name	Email - main
1.	GLOBAL	Suketoshi Taba	CIMMYT, Int.	s.taba@cgiar.org
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39.	Yugoslavia		Maize Research Institute	

APPENDIX 3. Global Maize Genetic Resources Conservation meeting, 5-6 May 2006

Sponsored by the Global Crop Diversity Trust, World Bank and CIMMYT, Int.
PROGRAM

Friday May 5, 2006: Consultation on development of a global strategy for the effective and efficient ex-situ conservation of maize genetic resources

08:00-08:20	Dr. Dave Ellis. USDA, Plant Genetic Resources Preservation Program - Maize collections at the National Center for Genetic Resources Preservation	Suketoshi Taba
08:20-08:40	Sara Hearne, IITA, Nigeria, West Africa Region Maize germplasm conservation, utilization and management in the West African Region	
08:40-09:30	Brigitte Laliberté, Global Crop Diversity Trust, Rome, Italy Global MAIZE conservation system and the role of the Trust	
09:30-10:10	Discussion on a global TEOSINTE strategy: conservation, management, and networking: Identification of most important populations How to management through a network	J. Sanchez / S. Taba
10:10-10:40	Discussion on a global TRIPSACUM strategy: conservation, management, and networking: Who are the partners, where is the expertise on collecting and conservation? How to produce seeds for conservation and use?	D. Costich / S. Hearne
10:40-11:00	Coffee break	
11:00-11:30	Discussion on global MAIZE strategy: conservation, management, and networking	Goodman / Sanchez
11:30-13:30	Development of the global maize genetic resources strategy for ex-situ conservation – small groups:	
	National / Regional / Global Collaboration: Sharing of responsibilities Safety-duplication Role of international and regional centers/networks	Costich / Zanetta / Ellis / Perales
	Role of National Germplasm Banks: Participation in a global system in conservation, regeneration, characterization, documentation, distribution and access	Sevilla / Has / Jampatong / Muthamia
	Information on accessions and sharing of databases: Challenges and opportunities for collaboration	Hernandez / Teixeira / Gardner / Rincon
	Teosinte and <i>Tripsacum</i> conservation: Components into a global maize conservation strategy	Sanchez / Hearne / Gonzalez / Fuentes
13:30-14:30	Lunch in CIMMYT Cafeteria	
14:30-16:00	Group reports	Goodman / Taba
16:00-16:30	Coffee break	
16:30-17:00	Future perspectives from the consultation on the global maize strategy for ex-situ conservation and networking	
17:00-18:00	Further comments, discussions, ordering of priorities and adjourn	
18:00-21:00	Farewell cocktail and dinner for participants in the Guest House.	

Saturday May 6, 2006: Small group expert committee meeting on the global maize strategy of ex-situ conservation

08:00-10:00	Expert committee meeting on the results of the consultation on development of maize crop strategy	Goodman
	Suketoshi Taba, Jesus Sanchez, Ricardo Sevilla, Juan Manuel Hernandez, Dave Ellis, Candice Garder, Sarah Hearne, Denise Costich, Anne Zanetto and any other interested partner	
10:00-10:30	Coffee break	
10:30-12:30	Elaboration of conclusions and recommendations	

APPENDIX 4 Participants in the Maize Germplasm Network Meeting, CIMMYT, May 2006

	Country/Organisation	Name and contact details
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APPENDIX 5: The wild relatives of maize

A3.1 Teosinte genetic resources

Teosinte, the closest relative of maize, is considered to have greatly influenced the high genetic variability and development of the principal Mesoamerican maize landraces. After several decades of studies, the hypothesis of teosinte as the wild ancestor of maize has become widely accepted. Despite profound differences in ear and plant morphology, teosinte and maize are very close genetically; they hybridize and produce viable, fully fertile hybrids. The inheritance of key traits distinguishing maize and teosinte has been under study by Doebley and co-workers for the last two decades. Several of the morphological traits are under the control of multiple genes and exhibit quantitative inheritance; there are five or six regions of the genome that have very strong effects on the observed differences between maize and teosinte (Doebley, 2004). However, a key event in maize domestication, the liberation of the kernel from the hardened, protective casing that envelops the kernel in teosinte is controlled by a single gene (Wang *et al.*, 2005).

Teosinte is represented by annual and perennial diploid species ($2n = 20$) and by a tetraploid species ($2n = 40$). They are found within the tropical and subtropical areas of Mexico, Guatemala, Honduras, and Nicaragua as isolated populations of variable population sizes, occupying from less than one ha to several hundreds of square kilometers. The distribution of teosinte extends from the southern part of the cultural region known as Arid America, in the Western Sierra Madre of the State of Chihuahua and the Guadiana Valley in Durango, to the western part of Nicaragua, including practically the entire western part of Mesoamerica. A point worth highlighting with regard to the geographic distribution of teosinte is that populations have specific climate, soil, and human circumstances under which they can be found (Sanchez *et al.*, 1998).

Teosintes comprise seven taxa (Appendix 5, Table 1) divided into two sections and five species: section *Luxuriantes* Doebley & Iltis comprises *Zea perennis* (Hitch.) Reeves & Mangelsdorf, *Zea diploperennis* Iltis, Doebley & Guzmán, *Zea luxurians* (Durieu & Ascherson) Bird and *Zea nicaraguensis* Iltis & Benz. Section *Zea* contains three subspecies of *Zea mays*, *Zea mays* ssp. *parviglumis* Iltis and Doebley (race Balsas), *Zea mays* ssp. *mexicana* (Schrader) Iltis (races Chalco, Central Plateau and Nobogame), and *Zea mays* ssp. *huehuetenangensis* (Iltis and Doebley) Doebley (race Huehuetenango). Over the last 25 years, great advances have been made in knowledge of genetic diversity, phylogenetic relationships and the natural distribution of teosinte in Mexico, Guatemala and Nicaragua (Doebley *et al.*, 1984; Sánchez *et al.*, 1998; Matsuoka *et al.*, 2002; Doebley, 2004; Fukunaga *et al.*, 2005).

The major teosinte collections in germplasm banks are those of INIFAP, CIMMYT, USDA-ARS and Universidad de Guadalajara (Appendix 5, Table 2). Only CIMMYT and USDA-ARS have long-term storage facilities. Of the 805 accessions reported by the above institutions, only partial data are available for users: 40% have passport data and only 25% have inventory data. On average, 750g are stored per accession at the Universidad de Guadalajara and about 600g at INIFAP. It is important to stress that most populations have been sampled in small seed quantities, mostly for genetic and morphological studies. Sampling for long-term conservation will be required for most populations.

Although the samples on hand may generally represent the variation known and expected in Mexico and Central America, it has not been possible to verify many existing reports of teosinte in the field, due to the difficulties of reaching sites, budget constraints and lack of equipment for exploring and collecting. It is difficult to estimate the danger of extinction for teosinte with precision, however, based on observations over the last 25 years, all populations are threatened. Several populations have practically disappeared, except, until recently, for some populations in the Balsas Basin, which includes many populations from the states of Guerrero, Michoacán, and Mexico (Sánchez *et al.*, 2004; Wilkes, 2006). However, a recent survey (Dr. G. Wilkes, Dr. S. Taba and Dr. J. Sanchez; December, 2004) of southern and northern Guatemala teosinte populations found them nearing extinction. Over the last 500 years, human activities such as deforestation, urbanization (road building) and cattle grazing have been identified as the major threats to teosinte. However, according to Dr. G. Wilkes, the most important threat is when the cultivation of maize landraces is abandoned. Because of these threats, permanent monitoring programs and in-situ conservation projects with participation of local farmer communities are critically needed. For the short term, collecting and ex-situ

conservation activities are urgent in Guatemala, Nicaragua and several sites in Mexico.

A3.1.1 Recommendations for teosinte preservation and use

Ex-situ teosinte seed conservation

- When collecting existing populations, use appropriate sample size for seed distribution of duplicates and for users.
- Monitor seed viability of accessions in the banks.
- Upgrade seed storage facilities.

In-situ teosinte conservation

- Designate in-situ sites or populations for protection in Mexico, Guatemala, and Nicaragua.
- Monitor the in-situ populations for changes in demography and genetic diversity.

Characterization/evaluation and use

- Characterize with minimum phenotypic descriptors.
- Characterize with molecular markers.
- Develop a database characterizing teosinte populations and races.
- Compile information on characterization, use, and prebreeding with teosinte.
- Make data web-accessible.
- Teosinte database
- Compile passport data of the accessions at all banks.
- Make seed increases, and inventory the accessions as necessary.
- Compile in-situ monitoring data.
- Make seed distribution records available.

A3.2 *Tripsacum* genetic resources

The genus *Tripsacum* is the genus most closely related to *Zea*. Two easily discerned morphological features distinguish *Tripsacum* species from *Zea* species. First, *Tripsacum* inflorescences have both distal male spikelets and basal female spikelets, unlike *Zea* in which there are separate male and female inflorescences (although teosinte, and more rarely maize, do form some mixed inflorescences). Second, *Tripsacum* fruitcases are less indurate, more cylindrical in cross section, and rectangular-trapezoidal in outline.

Tripsacum L. is a genus of nearly 20 recognized taxa (Appendix 5, Table 3), all of which are native to the New World. They are distributed from central and eastern United States to Paraguay; growing from sea level to nearly 2,700 meters in tropical and subtropical forests, savannas, grasslands, dry scrubland, and temperate forests. Systematic treatment is difficult because hybridization, polyploidy, and apomixis occur throughout the genus. In addition, there is insufficient herbarium material, especially from South America, for a comprehensive study. *Tripsacum* and *Zea* comprise subtribe Tripsacinae, tribe Andropogoneae, subfamily Panicoideae of family Poaceae (GPWG, 2001). *Tripsacum* is a more distant and diverse American relative of maize than the teosintes. Mexico and Guatemala are the centers of diversity for both genera.

Tripsacum is widely distributed in the Americas, however, it is not a very common plant. The species are perennial forage grasses, but even the more widely spread *T. dactyloides* is not common enough to be of importance. Populations of various size exist, but their colonizing ability is inferior to that of more aggressive grasses, such as *Panicum maximum*. One species, *T. andersonii*, is a natural *Tripsacum* x *Zea* hybrid (Talbert et al. 1990; Larson and Doebley 1994; Berthaud et al. 1997). *Zea luxurians* (an n=10 teosinte) was identified as the *Zea* parent, while triploid *T. latifolium* (2n=3x=54), the result of a hybridization between *T. latifolium* (2x) and *T. maizar* (2x), is proposed to be the *Tripsacum* parent (Berthaud et al. 1997) This species has been introduced as a forage grass throughout the tropics.

Tripsacum species display considerable variation in ploidy level, with a haploid chromosome number of n=18 (Table 3): a few are strictly diploid, others show a range from diploid to tetraploid, and in some cases, pentaploid and hexaploid, while still others are strictly tetraploid. Our imperfect knowledge in this area is highlighted by the results of a population study of Mexican *Tripsacum* species: in a survey of ploidy levels (2x,

3x, 4x, 5-6x) in 174 populations, 15 out of 37 ploidy level-taxon combinations (41%) had never been reported before, and in more than half of the cases, the “new” ploidy was triploid (Berthaud et al. 1997).

With respect to reproductive biology, all of the diploids are sexual, while the polyploids exhibit facultative diplosporic, pseudogamous apomixis. This signifies a complete breakdown of meiosis in the embryo sac, and the development of embryos that are genetically identical to the maternal plant. Endosperm development does require fertilization by a reduced or unreduced sperm cell. Male meiosis is also disrupted, resulting in 25% of the pollen grains with variable ploidy (Farquharson 1955; Burson et al. 1990; Leblanc et al. 1995). Despite this dysfunction, sexual offspring are produced on rare occasions by the apomictic polyploids (Grimanelli et al. 2003). This low level of sexual reproduction allows for gene flow among diploid and polyploid species in areas of sympatry, perhaps underlying the complex pattern of overlapping and highly variable morphology seen in the centers of species diversity in Mexico and Guatemala (Randolph 1970; Li et al. 1999; Springer and Dewald 2004).

The most important collections of *Tripsacum* are the field collection at the CIMMYT experiment station at Tlaltizapan, Morelos, Mexico, and the USDA live germplasm collections at Miami, FL, and Woodward, OK, USA.

Maize and *Tripsacum* have been hybridized; de Wet and Harlan (1978), among others, have reported successful crosses with diploid and tetraploid species; however, no spontaneous hybrids have been confirmed. (other than *T. andersonii*). Maize breeding programs using *Tripsacum* germplasm are not common; the more alien nature of *Tripsacum* germplasm makes its transfer into maize extremely complex. A transfer program for apomixis was underway at CIMMYT during the late 1990's and a program for resistance to *Striga hermonthica*, started at CIMMYT, is underway at IITA (Gurney et al., 2003). Utilizing *Tripsacum*-introgressed maize lines developed at the Crop Evolution Laboratory of the University of Illinois in the 1970s by Harlan, De Wet and coworkers (salvaged by Brian Kindiger), Duvick et al. (2006) are successfully altering the fatty acid composition of maize.

Tripsacum, as a close relative to maize, is an obvious source of genes for the improvement of this important crop plant, one that is critical to the world food supply. Past efforts have focused solely on *T. dactyloides*. A thorough study of the genus *Tripsacum* in its entirety will provide a “roadmap” for plant breeders and geneticists to expand their search to all of the natural diversity available in the genus. As the agronomic potential of *Tripsacum* itself is starting to be realized through its increasing use for pasture, forage, and soil erosion control throughout the world (Springer and Dewald 2004), continued improvement and development of the genus is predicated upon a strong commitment to the preservation of natural populations and the development of germplasm resources.

A3.2.1 Recommendations for *Tripsacum* preservation and use

- Coordinate all *Tripsacum* preservation, collection and research efforts with those of the teosinte project.
- Complete inventory of germplasm in *ex situ* collections at CIMMYT and at USDA stations in Miami and Woodward, characterizing the accessions with phenotypic descriptors and molecular markers in one web-accessible database.
- Establish priorities for collection from natural populations based on representation of taxa in existing *ex situ* collections.
- Identify a core collection that could be replicated at other sites, including IITA.
- Revisit and monitor the Mexican *Tripsacum* populations included in the original survey carried out by The Apomixis Research Project (co-sponsored by IRD [Institute of Research for Development, France] and CIMMYT) from 1989 to 1994.
- Increase seed available for distribution through CIMMYT.

REFERENCES

1. Berthaud, J., Y. Savidan, M. Barre, and O. Leblanc. 1997. *Tripsacum*. In: D. Fucillo, L. Sears and P. Stapleton, eds. Biodiversity in Trust. Cambridge University Press, Cambridge, U.K.
2. Burson, B. L., P. W. Voigt, R. A. Sherman, and C. L. Dewald. 1990. Apomixis and sexuality in Eastern Gamagrass. *Crop Science* 30:86-89.

3. De Wet J.M.J., D. Brink, and C.E. Cohen. 1983a. Systematics of *Tripsacum* Section *Fasciculata* (Gramineae). *Am. J. Bot.* 70:1139-1146.
4. De Wet J.M.J., G.B. Fletcher, K.W. Hilu, and J.R. Harlan. 1983b. Origin of *Tripsacum andersonii* (Gramineae). *Am. J. Bot.* 70:706-711.
5. De Wet J.M.J., J.R. Gray, and J.R. Harlan. 1976. Systematics of *Tripsacum* (Gramineae). *Phytologia* 33:203-227.
6. De Wet, J.M.J. and J.R. Harlan 1978. *Tripsacum* and the origin of maize. Pp. 129-141 in: D.B. Walden (ed.). *Maize Breeding and Genetics*. John Wiley & Sons.
7. De Wet J.M.J., J.R. Harlan, and D. Brink. 1982. Systematics of *Tripsacum dactyloides* (Gramineae). *Am. J. Bot.* 69:1251-1257.
8. De Wet J.M.J., D.H. Timothy, K.W. Hilu, and G.B. Fletcher. 1981. Systematics of South American *Tripsacum* (Gramineae). *Am. J. Bot.* 68:269-276.
9. Doebley, J. F. 1990. Molecular evidence and the evolution of maize. *Econ. Bot.* 44 (3 supplement): 6- 27.
10. Doebley, J. 2004. The genetics of maize evolution. *Ann. Rev. Genet.* 2004, 38: 37-59.
11. Doebley, J.F., M.M. Goodman, and C.W. Stuber. 1984. Isozyme variation in *Zea* (Gramineae). *Syst. Bot.* 9: 203-218.
12. Duvick, S.A., L.M. Pollak, J.W. Edwards, and P.J. White. 2006. Altering the fatty acid composition of Corn Belt corn through *Tripsacum* introgression. *Maydica* 51: 409-416.
13. Farquharson, L. I. 1955. Apomixis and polyembryony in *Tripsacum dactyloides*. *American Journal of Botany* 42:737-743.
14. Fukunaga, K., J. Hill, Y. Vigoroux, Y. Matsuoka, J. Sanchez G., K. Liu, E.S. Buckler, and J. Doebley. 2005. Genetic diversity and population structure of teosinte. *Genetics* 169: 2241-2254.
15. G.P.W.G. [Grass Phylogeny Working Group]. 2001. Phylogeny and subfamilial classification of the grasses (Poaceae). *Annals Mo. Bot. Garden* 88:373-457.
16. Grimanelli, D., M. Garcia, E. Kaszas, E. Perotti, and O. Leblanc. 2003. Heterochronic expression of sexual reproductive programs during apomictic development in *Tripsacum*. *Genetics* 165:1521-1531.
17. Gurney, A. L., D. Grimanelli, F. Kanampiu, D. Hoisington, J. D. Scholes, and M. C. Press. 2003. Novel sources of resistance to *Striga hermonthica* in *Tripsacum dactyloides*, a wild relative of maize. *New Phytologist* 160:557-568.
18. Iltis, H.H. and J.F. Doebley. 1980. Taxonomy of *Zea* (Gramineae).II. Subspecific categories in the *Zea mays* complex and a generic synopsis. *Amer. J. Bot.* 67: 994-1004.
19. Iltis, H.H and B.F. Benz. 2000. *Zea nicaraguensis* (Poaceae), a new teosinte from Pacific Coastal Nicaragua: *Novon* 10: 382-390.
20. Larson, S. R., and J. Doebley. 1994. Restriction site variation in the chloroplast genome of *Tripsacum* (Poaceae): Phylogeny and rates of sequence evolution. *Systematic Botany* 19:21-34.
21. Leblanc, O., M. D. Peel, J. G. Carman, and Y. Savidan. 1995. Megasporogenesis and megagametogenesis in several *Tripsacum* species (Poaceae). *American Journal of Botany* 82:57-63.
22. Li, Y. G., C. L. Dewald, and P. L. Sims. 1999. Genetic relationships within *Tripsacum* as detected by RAPD variation. *Annals of Botany* 84:695-702.
23. Matsuoka, Y., Y. Vigouroux, M.M. Goodman, J. Sanchez G., E. Buckler and J. Doebley 2002. A single domestication for maize shown by multilocus microsatellite genotyping. *Proceedings of the National Academy of Sciences* 99: 6080-6084.
24. Randolph, L. F. 1970. Variation among *Tripsacum* populations of Mexico and Guatemala. *Brittonia* 22:305-337.
25. Sánchez G., J.J., T.A. Kato Y., M. Aguilar S., J.M. Hernández C., A. López R. and J.A. Ruíz C. 1998. Distribución y caracterización del teocintle. Libro Técnico No. 2. CIPAC-INIFAP. 150p.
26. Sánchez G., J.J., R. Miranda M., L. De la Cruz L. 2004. Recolección y conservación de Las especies silvestres del género *Zea* (Teocintle) en México. *Informe De Actividades 2002-2003* Preparado para la Secretaría de Medio Ambiente y Recursos Naturales Subsecretaría de Gestión para la Protección Ambiental Dirección General de Vida Silvestre.
27. Springer, T. L., and C. L. Dewald. 2004. Eastern gamagrass and other *Tripsacum* species. Pp. 955-973 in L. E. Moser, B. L. Burson, and L. E. Sollenberger, eds. *Warm-Season (C4) Grasses Agronomy Monograph 45*. American Society of Agronomy, Madison, WI.
28. Talbert, L. E., J. Doebley, S. R. Larson, and V. L. Chandler. 1990. *Tripsacum andersonii* is a natural hybrid involving *Zea* and *Tripsacum*: Molecular evidence. *American Journal of Botany* 77:722-726.

29. Wang, H., T. Nussbaum-Wagler, B. Li, Q. Zhao, Y. Vigouroux, M. Faller, K. Bomblies, L. Lukens, J.F. Doebley. 2005. The origin of the naked grains of maize. *Nature* 436: 714-719.
30. Wilkes, G. 1967. Teosinte: the closest relative of maize. *Bussey Inst. Harvard Univ.* 159p.
31. Wilkes, G. 2004. Corn, strange and marvelous: But is a definitive origin known? Pp.3-63 In: C.W. Smith, *et al* (Ed) *Corn: Origin, History, Technology, and Production*. John Wiley & Sons.
32. Wilkes, G. 2006. Teosinte evolution and *in-situ* conservation in Guerrero, Mexico: *Maydica* (in press).
33. Zuloaga, F.O., O. Morrone, G. Davidse, T.S. Filgueiras, P.M. Peterson, R.J. Soreng, and E. Judziewicz. 2003. *Catalogue of New World Grasses (Poaceae): III. Subfamilies Panicoideae, Aristidoideae, Arundinoideae, and Danthonioideae*. Smithsonian Institution, Washington, D.C.

Appendix 5, Table 1. Nomenclature for maize and teosinte

Wilkes, 1967; 2004	Doebley, 1990; Iltis and Benz, 2000
Section: <i>Euchlaena</i> (Schrader) Kuntze	Section: <i>Zea</i>
<i>Zea mexicana</i> (Schrader) Kuntze	-
Chalco	<i>Zea mays</i> L. subsp. <i>Mexicana</i> (Schrader) Iltis
Central Plateau	<i>Zea mays</i> L. subsp. <i>Mexicana</i> (Schrader) Iltis
Nobogame	<i>Zea mays</i> L. subsp. <i>Mexicana</i> (Schrader) Iltis
Balsas	<i>Zea mays</i> L. subsp. <i>Parviglumis</i> Iltis & Doebley
Huehuetenango	<i>Zea mays</i> L subsp. <i>Huehuetenangensis</i> (Iltis & Doebley) Doebley
Section: <i>Luxuriantes</i> (Durieu)	Section: <i>Luxuriantes</i>
Guatemala	<i>Zea luxurians</i> (Durieu & Ascherson) Bird
<i>Zea perennis</i> (Hitch.) Reeves & Mangelsdorf	<i>Zea perennis</i> (Hitch.) Reeves & Mangelsdorf
<i>Zea diploperennis</i> Iltis, Doebley & Guzmán	<i>Zea diploperennis</i> Iltis, Doebley & Guzmán
	<i>Zea nicaraguensis</i> Iltis & Benz
Maize	
Section: <i>Mays</i> L.	Section: <i>Zea</i>
<i>Zea mays</i> L.	<i>Zea mays</i> L. subsp. <i>Mays</i> Iltis & Doebley

Appendix 5, Table 2. Teosinte collections in Mexico and the United States

Race / species	UdeG	INIFAP	CIMMYT	USDA (GRIN) ^b
Balsas	96	135	50	120
Chalco	18	44	45	16
Central Plateau	37	55	18	12
Nobogame	2	4	2	6
<i>Zea diploperennis</i>	2	7	2	14
<i>Zea perennis</i>	1	4	2	10
Huehuetenango			1	7
<i>Zea luxurians</i>			1	21
<i>Zea nicaraguensis</i>			1	2
Unknown			40	1
Total accessions	156	249 ^a	162	209

^a Includes 100 accessions from Universidad de Guadalajara, 2004

^b(www.ars-grin.gov) and Plant Inventory No. 173, 174, 176, 177, 179, 181 (USDA).

Appendix 5, Table 3. Genus *Tripsacum* in the Americas

Species	Species Distribution*	Ploidy
SECTION: <i>Tripsacum</i>		
<i>andersonii</i> J.R.Gray (1976) [<i>Tripsacum</i> 3X (54) + <i>Zea</i> 1X (10)]	Beli, Boli, Braz, Cari, Colo, CoRi, Ecu, ElSa, FrGu, Guat, Guya, Hond, Mexi, Nica, Pana, Peru, Suri, Vene.	2n=64
<i>australe</i> H.C. Cutler & E.S. Anderson (1941)	Boli, Braz, Colo, Ecu, FrGu, Guya, Para, Peru, Suri, Vene.	2x, 4x
<i>bravum</i> J.R. Gray (1976)	Mexi	2x, 3x, 4x, 6x
<i>cundinamarce</i> de Wet & Timothy (1981)	Colo	2x
<i>dactyloides</i> (L.) L. (1759)	Beli, Boli, Braz, Cari, Colo, CoRi, Ecu, FrGu, Guat, Guya, Hond, Mexi, Pana, Para, Suri, USA, Vene.	2x, 3x, 4x
<i>floridanum</i> Porter ex Vasey (1892)	USA (Fl), Cuba	2x
<i>intermedium</i> de Wet & J.R. Harlan (1982)	Guat, Hond, Mexi.	4x, 5x
<i>latifolium</i> Hitchcock (1906)	Beli, Boli, Cari, CoRi, Guat, Hond, Mexi, Nica, Pana, Suri.	2x, 4x
<i>manisuroides</i> de Wet & J.R. Harlan (1982)	Mexi.	2x
<i>peruvianum</i> de Wet & Timothy (1981)	Ecu, Peru.	4x, 5x
<i>zopilotense</i> Hern.-Xol. & Randolph (1950)	Guat, Mexi.	2x, 3x, 4x
SECTION: <i>Fasciculata</i>		
<i>jalapense</i> deWet & Brink (1983)	ElSa, Guat, Mexi	4x
<i>lanceolatum</i> Rupr. ex E. Fourn. (1881)	Guat, Hond, Mexi, Pana, USA.	4x
<i>laxum</i> Nash (1909)	Beli, Cari, Colo, CoRi, ElSa, FrGu, Guat, Mexi.	2x
<i>maizar</i> Hern.-Xol. & Randolph (1950)	CoRi, Guat, Mexi.	2x, 3x, 4x
<i>pilosum</i> Scribn. & Merr. (1901)	Guat, Hond, Mexi, USA.	2x, 3x, 4x

- Sources: Species names, author(s), year of publication (The International Plant Names Index (IPNI) 2005 [<http://www.ipni.org>] with corroboration from original literature); Species Distributions (Zuloaga et al. 2003); all other information (Berthaud et al. 1997; de Wet et al. 1983a; de Wet et al. 1983b; de Wet et al. 1976; de Wet et al. 1982; de Wet et al. 1981; Wilkes 2004).
- Beli=Belize, Boli=Bolivia, Braz=Brazil, Cari=Caribbean, Colo=Colombia, CoRi=Costa Rica, Ecu=Ecuador, ElSa=El Salvador, Fl=Florida(USA), FrGu=French Guiana, Guat=Guatemala, Guya=Guyana, Hond=Honduras, Mexi=Mexico, Nica=Nicaragua, Pana=Panama, Para=Paraguay, Suri=Surinam, USA=United States of America, Vene=Venezuela.

APPENDIX 6: Summary of the questionnaire on the maize collections

Country	Institution	Collection Manager data	Accession category		No. of accessions	No. of introductions ¹			
			Type accession	Country of origin		Own country	Other countries		
Argentina	INTA	MSc. Marcelo Edmundo Ferrer mferrer@pergamino.inta.gov.ar	Landraces	Argentina	2,430	2,430			
				Total		2,430	2,430	0	
			Improved populations and synthetics	Argentina*	15	15			
				Total	15	15	0		
			Open pollinated varieties	Argentina	3	3			
				Total	3	3	0		
			Inbreds	Argentina	55	55			
				Total	55	55	0		
			GRAND TOTAL				2,503	2,503	0
			Australia	Australian Tropical Crops & Forages Germplasm Collection	Peter Lawrence peter.lawrence@dpi.qld.gov.au	Landraces	Others Countries	103	
Total		103					0	103	
Improved populations and synthetics	Australia	76				76			
	Others Countries	26					26		
Total	102	76				26			
Open pollinated varieties	Australia	20				20			
	Others Countries	75					75		
Total	95	20				75			
Inbreds	Australia	90				90			
	Others Countries	319					319		
Total	409	90	319						
GRAND TOTAL				709	186	523			
Austria	Austrian Agency for Health and Food Safety	Dr. Paul Freudenthaler genetische.ressourcen@ages.at	Landraces	Austria	16	16			
				Bosnia and Herzegovina	1		1		
				China	1		1		
				Slovakia	1		1		
				USA	3		3		
				Yugoslavia	1		1		
				Total	23	16	7		
			Improved populations and synthetics	Brazil	1		1		
				Netherlands	1		1		
			Nepal	2		2			
Total	4	0	4						
GRAND TOTAL				27	16	11			
Bolivia	Centro de Invest. Fitogenéticas de Pairumani	Lic. Lorena Guzmán fitogen@fundacionpatino.org	Landraces	Bolivia	1,478	1,478			
				Chile	23		23		
			Total	1,501	1,478	23			
			Improved populations and synthetics	Bolivia	2	2			
				Total	2	2	0		
			Open pollinated varieties	Bolivia	10	10			
				Total	10	10	0		
			Inbreds	Bolivia	50	50			
				CIMMYT	20		20		
			Total	70	50	20			
Teosinte	Mexico	1		1					
	Total	1	0	1					
GRAND TOTAL				1,584	1,540	44			
Brazil	Embrapa Milho e Sorgo	Flavia França Teixeira flavia@cnpms.embrapa.br	Landraces	Brazil	3,153	3,153			
				Others countries*	288		288		
			Total	3,441	3,153	288			
			Improved populations and synthetics	Brazil	222	222			
				Total	222	222	0		
			Teosinte	Mexico	6		6		
				Total	6	0	6		
			Tripsacum	Unknown	1		1		
				Total	1	0	1		
			GRAND TOTAL				3,670	3,375	295
Chile	Instituto de Investigaciones Agropecuarias	Erika Salazar Suazo esalazar@inia.cl	Landraces	Chile	949	949			
				Total	949	949	0		
			Open pollinated varieties	Chile	2	2			
				Bolivia	2		2		
			Others countries	16		16			
			Total	20	2	18			
			Inbreds	Chile	506	506			
				Total	506	506	0		
			GRAND TOTAL				1,475	1,457	18

* Maybe available under MTA.

*Mexico, USA, Guatemala, Honduras, El Salvador, Rep Dominicana, Cuba, France, Holland, Italy

* Uruguay, Argentina USA

Country	Institution	Collection Manager data	Accession category		No. of accessions	No. of introductions ¹		
			Type accession	Country of origin		Own country	Other countries	
China	Institute of Crop Science , C A A S	Xinxiong Lu xxlu@caas.net.cn	Landraces	China	13,415	13,415		
				Israel	6		6	
				Albania	17		17	
				Argentina	12		12	
				Australia	12		12	
				Belgium	5		5	
				Brazil	4		4	
				Bulgaria	21		21	
				Canada	13		13	
				Chile	10		10	
				Czech Republic	3		3	
				Egypt	18		18	
				England	12		12	
				Ethiopia	2		2	
				France	23		23	
				Germany	34		34	
				Guatemala	1		1	
				Hungary	120		120	
				India	1		1	
				Indonesia	3		3	
				Iran	9		9	
				Italy	37		37	
				Japan	48		48	
				Malaysia	1		1	
				Mexico	177		177	
				Mongolia	4		4	
				Netherlands	6		6	
				Pakistan	6		6	
				People's Republic of Korea	32		32	
				Peru	1		1	
				Philippines	1		1	
				Poland	12		12	
				Puerto Rico	7		7	
				Republic of Yemen	2		2	
				Romania	18		18	
				Russia	44		44	
				Somali	2		2	
				Thailand	16		16	
				Turkey	8		8	
				Ukraine	10		10	
				Unknown	233		233	
USA	238		238					
Vietnam	9		9					
Yugoslavia	78		78					
Zaire	3		3					
Total	14,734	13,415	1,319					
	Improved populations and synthetics							
	China	61	61					
	Total	61	61	0				
	Inbreds							
	China	2,791	2,791					
	Australia	3		3				
	Austria	3		3				
	Bulgaria	6		6				
	Canada	38		38				
	Czech Republic	3		3				
	Egypt	1		1				
	France	44		44				
	Germany	1		1				
	Hungary	5		5				
	Italy	57		57				
	Japan	12		12				
	Mexico	238		238				
	Nigeria	8		8				
	People's Republic of Korea	16		16				
	Poland	4		4				
	Portugal	1		1				
	Republic of Yemen	4		4				
	Romania	14		14				
	Russia	18		18				
	South Africa	2		2				
	Spain	2		2				
	Unknown	52		52				
	USA	511		511				
	Yugoslavia	95		95				
	Total	3,929	2,791	0				
	GRAND TOTAL	18,724	16,267	1,319				
Colombia	CORPOICA	Alejandro Alberto Navas Arboleda anavasa@corpoica.org.co	Landraces	Colombia	1,768	1,768		
				Africa	2		2	
				Antigua	8		8	
				Argentina	10		10	
				Barbados	12		12	
				Bolivia	376		376	
				Brazil	1		1	
				Chile	33		33	
				CIMMYT	27		27	
				Cuba	37		37	
				Ecuador	395		395	
				Grenada	16		16	
				Guadalupe	16		16	
				Guatemala	13		13	
				Haiti	26		26	
				India	3		3	
				Indonesia	2		2	
				Jamaica	2		2	
				Martinique	1		1	
				Mexico	225		225	
				Panama	90		90	
				Peru	113		113	
				Puerto Rico	14		14	
				Republic dominicana	68		68	
				Santa Croix	3		3	
				Santa Lucia	4		4	
				Thailand	2		2	
				Trinidad y Tobago	30		30	
				USA	14		14	
				Venezuela	435		435	
				Total	3,746	1,768	1,978	
					Improved populations and synthetics			
					Colombia	406	406	
					Total	406	406	0
					GRAND TOTAL	4,152	2,174	1,978

Country	Institution	Collection Manager data	Accession category		No. of accessions	No. of introductions ¹	
			Type accession	Country of origin		Own country	Other countries
Costa Rica	CATIE	Dr. Andreas W. Ebert awebert@catie.ac.cr	Landraces	Costa Rica	60	60	
				El Salvador	6		6
				Guatemala	54		54
				Honduras	6		6
				Mexico	26		26
				Nicaragua	3		3
				Panama	15		15
				Russia	5		5
				USA*	244		244
				Total	419	60	359
				GRAND TOTAL	419	60	361
* These 244 accessions have been donated by USDA and are registered in the GRIN database. Countries of origin are Argentina, Turkey, Czechoslovakia, USA, Canada, Russia, Afghanistan, Philippines, Bolivia, Brazil, Syria, Spain, Chile, Yugoslavia, and Ecuador.							
Czech Republic	RIPC Prague-Ruzyně	Vera Chytilova chytilova@genobanka.cz	Improved populations and synthetics	USA	7		7
				Total	7	0	7
			Open pollinated varieties	Czech Republic	1	1	
				Germany	1		1
				Hungary	2		2
				Poland	1		1
				unknown	8		8
				USA	36		36
				Total	49	1	48
			GRAND TOTAL	56	1	55	
			Czech Republic	Research Institute of Crop Production of Prague	Zdenek Stehno stehno@vurv.cz	Landraces	Czech Republic
Bulgary	1						1
Total	95	94					1
Open pollinated varieties	Czech Republic	3				3	
	Germany	1					1
	Hungary	5					5
	Poland	4					4
	URSS	2					2
	Unknown	25					25
	USA	44					44
	Yugoslavia	3					3
	Total	87				3	84
	Inbreds	Czech Republic				413	413
Austria		2					2
Bulgaria		5					5
Canada		35					35
France		28					28
Hungary		8					8
Italy		3					3
Netherland		3					3
Poland		11					11
Portugal		2					2
Romania	2					2	
URSS	4		4				
Unknown	10		10				
USA	77		77				
Yugoslavia	3		3				
Total	606	413	193				
GRAND TOTAL	788	510	278				
Ecuador	INIAP-DENAREF	Cesar Tapia Alvaro Monteros denaref@ecnet.ec	Landraces	Ecuador	1,055	1,055	
				Argentina	2		2
				Brazil	1		1
				Colombia	16		16
				Cuba	2		2
				Mexico	9		9
				Peru	133		133
				Rep. Dominicana	2		2
			USA	3		3	
			Total	1,223	1,055	168	
			Improved populations and synthetics	Ecuador	10	10	
				Total	10	10	0
			Open pollinated varieties	Ecuador	9	9	
				Total	9	9	0
			GRAND TOTAL	1,242	1,074	168	

Country	Institution	Collection Manager data	Accession category		No. of accessions	No. of introductions ¹		
			Type accession	Country of origin		Own country	Other countries	
Kenya	Kenya Agricultural Research Inst. Nat. Genebank of Kenya	Mr. Z.K. Muthamia ngbk@wananchi.com	Landraces	Kenya	1,116	NS*	NS	
				Total	1,116	0	0	
			Improved populations and synthetics	Kenya	4	4		
				Bulgaria	4		4	
				Ethiopia	2		2	
				France	5		5	
				Iran	1		1	
				Mexico	3		3	
				Senegal	2		2	
				South Africa	1		1	
Inbreds	USA	13		13				
	Yugoslavia	1		1				
	Zimbabwe	2		2				
	Total	38	4	34				
	Total	74	74	0				
GRAND TOTAL					1,228	78	34	
Mexico	CIMMYT, INT	Dr. Suketoshi Taba staba@cgiar.org	Landraces	Mexico	8,925	8,925		
				Afghanistan	19		19	
				Angola	9		9	
				Antigua	18		18	
				Argentina	1,153		1,153	
				Austria	7		7	
				Bahamas	1		1	
				Barbados	26		26	
				Belize	7		7	
				Bolivia	841		841	
				Brazil	3,137		3,137	
				British Virgin Island	54		54	
				Chile	451		451	
				China	26		26	
				Colombia	349		349	
				Congo	1		1	
				Costa Rica	392		392	
				Cuba	301		301	
				Ecuador	1,001		1,001	
				Egypt	1		1	
				El Salvador	105		105	
				Ethiopia	29		29	
				GRANDada	35		35	
				Guadalupe	34		34	
				Guatemala	1,029		1,029	
				Guiana Fr.	11		11	
				Guinea	1		1	
				Guyana	15		15	
				Haiti	59		59	
				Honduras	178		178	
				India	4		4	
				Israel	4		4	
				Jamaica	8		8	
				Kenya	2		2	
				Lebanon	7		7	
				Mali	58		58	
				Martinica	10		10	
				Morocco	52		52	
				Nepal	212		212	
				Nicaragua	74		74	
				Niger	1		1	
				Pakistan	2		2	
				Panama	195		195	
				Paraguay	567		567	
				Peru	1,219		1,219	
				Puerto Rico	42		42	
				Rep. Dominicana	216		216	
				St. Croix	15		15	
				St. Vincent	20		20	
				Sta. Lucia	8		8	
				Surinam	13		13	
				Thailand	1		1	
				Trinidad y Tobago	72		72	
				Uganda	4		4	
				Uruguay	977		977	
				USA	31		31	
				Venezuela	630		630	
				Yemen	2		2	
				Total	22,661	8,925	13,736	
				Improved populations and synthetics	CIMMYT	1,190	1,190	
					Total	1,190	1,190	0
				Open pollinated varieties	CIMMYT	1,092	1,092	
					Total	1,092	1,092	0
				Inbreds	CIMMYT	358	358	
					Total	358	358	0
				Teosinte	Mexico	159	159	0
					Guatemala	26		26
					Nicaragua	1		1
					Total	186	159	27
Tripsacum	Mexico	91	91	0				
	Belize	1		1				
	Brazil	1		1				
	CIMMYT	5		5				
	Colombia	13		13				
	Ecuador	1		1				
	Honduras	1		1				
	Peru	2		2				
	Trinidad y Tobago	1		1				
	USA	1		1				
	Venezuela	5		5				
	Total	122	91	31				
GRAND TOTAL					25,609	11,815	13,794	

Country	Institution	Collection Manager data	Accession category		No. of accessions	No. of introductions ¹	
			Type accession	Country of origin		Own country	Other countries
Pakistan	Plant Genetic Resources Programme Nat. Agric. Res. Center	Dr. Zahoor Ahmad zahmad51@hotmail.com	Landraces	Pakistan	507	507	0
				Total	507	507	0
			Improved populations and synthetics	Pakistan	74	74	
				Total	86	74	86
			GRAND TOTAL	667	581	86	
Paraguay	CRIA	Orlando J. Noldin orlandonoldin@gmail.com	Landraces	Paraguay	478	478	
			Improved populations and synthetics	Paraguay	15	15	
			GRAND TOTAL	493	493	0	
Peru	Universidad Nacional Agraria La Molina	Julían Chura Chuquija Ricardo Sevilla Panizo chura@lamolina.edu.pe rtc_cqar@inia.gob.pe	Landraces	Peru	3,000	3,000	
				Brazil	10		10
				Colombia	5		5
				Guatemala	6		6
				Mexico	12		12
			Venezuela	4		4	
			Total	3,037	3,000	37	
			Improved populations and synthetics	Peru	21	21	
				Total	21	21	0
			Open pollinated varieties	Peru	24	24	
Total	24	24		0			
Inbreds	Peru	1,361	1,361				
	Total	1,361	1,361	0			
GRAND TOTAL	4,443	4,406	37				
Romania	Agricultural Research and Development Institute	Dr. Ion Antohe ionantohe@icric.ro	Landraces	Romania	234	234	
				Different countries	31		31
				Total	265	234	31
			Improved populations and synthetics	Romania	20	20	
				Different countries	64		64
				Total	84	20	64
			Open pollinated varieties	Romania	19	19	
				Different countries	5		5
			Total	24	19	5	
			Inbreds	Romania	671	671	
Different countries	368			368			
Total	1,039	671		368			
GRAND TOTAL	1,412	944	468				
Romania	Suceava Genebank	Dr. Eng. Daniela Murariu dmurariu@suceava.astral.ro	Landraces	Romania	3227	3227	
				Canada	1		1
				Italy	1		1
				Unknown	15		15
				Total	3244	3227	17
			Improved populations and synthetics	Canada	5		5
				France	2		2
				Italy	2		2
				Unknown	118		118
				JRSS	1		1
USA	16		16				
Total	144	0	144				
Open pollinated varieties	Romania	126	126				
	Canada	1		1			
	Unknown	6		6			
Total	133	126	7				
Inbreds	Romania	834	834				
	Argentina	4		4			
	Canada	38		38			
	Germany	9		9			
	France	31		31			
	Italy	7		7			
	Mexico	10		10			
	Netherlands	10		10			
	Peru	1		1			
	Poland	24		24			
	Union of Soviet Socialist Republics	7		7			
	Turkey	5		5			
	Ukraine	2		2			
	USA	33		33			
	Russian Federation	33		33			
Unknown	187		187				
Total	1,235	834	401				
GRAND TOTAL	4,758	4,187	569				
Romania	Agricultural Research and Station TURDA	Dr. Ioan Has ioanhas@yahoo.com	Landraces	Romania	1,160	1,160	
				Austria	8		8
				Bulgaria	11		11
				Canada	107		107
				France	150		150
				Germany	115		115
				Hungary	22		22
				Italy	20		20
				Poland	49		49
				R. Czech	16		16
R. Moldova	69			69			
Russia	15			15			
Spain	24			24			
Swiss	1			1			
USA	136			136			
Yugoslavia	17		17				
Total	1,920	1,160	760				
Improved populations and synthetics	Romania	33	33				
	Germany	20		20			
	Spain	8		8			
Total	61	33	28				
Open pollinated varieties	Romania	267	267				
	Germany	9		9			
	Spain	2		2			
Total	278	267	11				
Inbreds	Romania	860	860				
	Austria	8		8			
	Bulgaria	11		11			
	Canada	107		107			
	France	150		150			
	Germany	86		86			
	Hungary	22		22			
	Italy	20		20			
	Poland	49		49			
	R. Czech	16		16			
	R. Moldova	69		69			
	Russia	15		15			
	Spain	14		14			
	Swiss	1		1			
	USA	136		136			
Yugoslavia	17		17				
Total	1,581	860	721				
GRAND TOTAL	3,840	2,320	1,520				

Country	Institution	Collection Manager data	Accession category		No. of accessions	No. of introductions ¹	
			Type accession	Country of origin		Own country	Other countries
Slovak Republic	Gene Bank, Research Inst. of Plant Production	Dr. Daniela Benedikova benedikova@vurv.sk	Landraces	Slovakia	204	204	1
				Bulgaria	1		2
				Ukraine	2		3
				Total	207	204	3
			Improved populations and synthetics	Slovakia	219	219	
				Australia	2		2
				Austria	1		1
				Bulgaria	6		6
				Canada	47		47
				Czech Republic	5		5
				France	35		35
				Germany	5		5
				Hungary	14		14
				Italy	3		3
				Japan	1		1
				Netherlands	3		3
				Poland	26		26
				Portugal	1		1
				Romania	6		6
				Spain	1		1
				URSS	16		16
			Unknown	18		18	
			USA	132		132	
Yugoslavia	11		11				
Total	552	219	333				
Open pollinated varieties	Slovakia	11	11				
	Albania	1		1			
	Czech Republic	5		5			
	Hungary	8		8			
	Korea	1		1			
	Poland	7		7			
	URSS	10		10			
	Unknown	51		51			
Yugoslavia	8		8				
Total	102	11	91				
Inbreds	Slovakia(SVK)	37		37			
	Total	37	0	37			
GRAND TOTAL				898	434	464	
Spain	Misión Biológica de Galicia (CSIC)	Dr. Amando Ordás aordas@mbg.cesga.es	Landraces	Spain	165	165	
				Portugal	17		17
				Total	182	165	17
			Improved populations and synthetics	Spain	28	28	
				USA	30		30
				Total	58	28	30
			Open pollinated varieties	USA	22		22
				Total	22	0	22
			Inbreds	Spain	59	59	
				Canada	15		15
				Portugal	7		7
				USA	114		114
				Total	195	59	136
GRAND TOTAL				457	252	205	
Sri Lanka	Plant Genetic Resources Centre	Non specified pgrc@sl.lk	Landraces	Sri Lanka	350	350	
				India	3		3
				Italy	3		3
				Mexico	200		200
				Nigeria	2		2
				Pakistan	3		3
				Philippines	4		4
				Thailand	50		50
				Unknown	72		72
				USA	3		3
				viatnam	4		4
			Total	694	350	344	
			Improved populations and synthetics	Sri Lanka	4	4	
				Total	4	4	0
			Open pollinated varieties	Sri Lanka	350	350	
				CIMMYT	15		15
			Total	365	350	15	
			Inbreds	Sri Lanka	90	90	
				CIMMYT	160		160
				Total	250	90	160
GRAND TOTAL				1,313	794	519	
Sweden	Nordic Gene Bank	Katarina Wedelsback Bladh katarina.wedelsback.bladh@nordgen.org	Improved populations and synthetics	Sweden	1	1	
				France	6		6
				Total	7	1	6
GRAND TOTAL				7	1	6	
Thailand	National Corn and Sorghum Research Center, Kasetsart Univ.	Sansern Jampatong snjpl@korat.loxinfo.co.th	Landraces	South and Central America	408		408
				Total	408	0	408
			Improved populations and synthetics	Thailand	153	153	
				CIMMYT	141		141
				USA	18		18
				Other countries*	289		289
			Total	601	153	448	
			Open pollinated varieties	USA	63		63
				Total	63	0	63
			Teosinte	CIMMYT	3		3
Total	3	0		3			
GRAND TOTAL				1,075	153	922	
Turkey	Aegean Agricultural Research Institute	Dr. A. Ertug Firat etae@aaari.gov.tr	Landraces	Turkey	1,574	1,574	
				Total	1,574	1,574	0
			Improved populations and synthetics	Turkey	7	7	
				Total	7	7	0
			Inbreds	Turkey	6	6	
				Total	6	6	0
GRAND TOTAL				1,587	1,587	0	

*Asian, South American, African, and European countries

Country	Institution	Collection Manager data	Accession category		No. of accessions	No. of introductions ¹		
			Type accession	Country of origin		Own country	Other countries	
Ukraine	NCPGRU	Dr. Victor K.Ryabchou ncpgru@kharkov.ukrtei.net	Improved populations and synthetics	Ukraine	894	894		
				Canada	16		16	
				France	4		4	
				Germany	12		12	
				Serbia and Montenegro	24		24	
				USA	50		50	
				Total	1,000	894	106	
				Inbreds	Ukraine	1,430	1,430	
					Canada	100		100
					France	91		91
Germany	86		86					
Serbia and Montenegro	112		112					
USA	400		400					
Total	2,219	1,430	789					
GRAND TOTAL				3,219	2,324	885		
Uruguay	INIA	Dr. Federico Condon fcondon@le.inia.org.uy	Landraces	Uruguay	852	852	0	
				Total	852	852	0	
				GRAND TOTAL				852
USA	North Central Regional Plant Introduction Station, ARS, USDA (NC-7)	Mr. Mark J. Millard mjmillard@astate.edu	Landraces	United States	1,320	1,320		
				Alghanistan	21		21	
				Albania	6		6	
				Algeria	23		23	
				Angola	19		19	
				Anguilla	1		1	
				Antigua and Barbuda	8		8	
				Argentina	317		317	
				Australia	17		17	
				Austria	29		29	
				Azerbaijan	4		4	
				Barbados	7		7	
				Belarus	1		1	
				Belize	4		4	
				Benin	1		1	
				Bhutan	6		6	
				Bolivia	464		464	
				Botswana	2		2	
				Brazil	512		512	
				Bulgaria	33		33	
				Burkina Faso	189		189	
				Burundi	50		50	
				Cambodia	2		2	
				Canada	45		45	
				Chad	3		3	
				Chile	607		607	
				China	18		18	
				Colombia	2,214		2,214	
				Costa Rica	134		134	
				Cuba	104		104	
				Czechoslovakia	12		12	
				Dominican Republic	95		95	
				Ecuador	108		108	
				Egypt	9		9	
				El Salvador	35		35	
				Eritrea	5		5	
				Ethiopia	156		156	
				Finland	2		2	
				Former Soviet Union	74		74	
				France	13		13	
				French Guiana	2		2	
				Georgia	6		6	
				Germany	5		5	
				Greece	1		1	
				Grenada	12		12	
				Guadeloupe	7		7	
				Guatemala	319		319	
				Guinea	140		140	
				Guyana	2		2	
				Haiti	19		19	
				Honduras	97		97	
				Hungary	87		87	
				India	36		36	
				Indonesia	4		4	
				Iran	6		6	
				Iraq	2		2	
				Israel	3		3	
				Italy	82		82	
				Jamaica	6		6	
				Japan	57		57	
				Jordan	1		1	
				Kazakhstan	1		1	
				Kenya	12		12	
				Korea, South	5		5	
				Lebanon	9		9	
				Macedonia	99		99	
				Madagascar	10		10	
				Maldives	1		1	
				Mali	19		19	
				Martinique	3		3	
				Mauritius	1		1	
				Mexico	2,460		2,460	
				Moldova	3		3	
				Morocco	10		10	
				Myanmar	1		1	
				Nepal	47		47	
				Netherlands	8		8	
				Nicaragua	53		53	
				Nigeria	3		3	
				Oman	23		23	
				Pakistan	37		37	
				Panama	29		29	
				Paraguay	68		68	
				Peru	1,969		1,969	
				Philippines	11		11	
				Poland	15		15	
				Portugal	201		201	
				Puerto Rico	22		22	
				Reunion	4		4	
Romania	43		43					
Russian Federation	19		19					
Saudi Arabia	8		8					
South Africa	48		48					
South America	6		6					
Spain	44		44					
Sri Lanka	1		1					
St. Lucia	2		2					
St. Vincent and Grenadines	5		5					
Sudan	3		3					
Suriname	5		5					
Swaziland	1		1					
Syria	9		9					
Tajikistan	1		1					
Thailand	7		7					
Togo	87		87					
Trinidad and Tobago	18		18					
Turkey	563		563					
U.S. Outlying Islands	1		1					
Uganda	3		3					
Ukraine	11		11					
United Kingdom	2		2					
Uruguay	424		424					
Uzbekistan	3		3					
Venezuela	53		53					
Virgin Islands (British)	15		15					
Virgin Islands (U.S.)	9		9					
Yemen	17		17					
Yugoslavia	295		295					
Zaire	32		32					
Zambia	281		281					
Zimbabwe	27		27					
Total	14,731	1,320	13,411					

Country	Institution	Collection Manager data	Accession category		No. of accessions	No. of introductions ¹	
			Type accession	Country of origin		Own country	Other countries
USA	North Central Regional Plant Introduction Station, ARS, USDA (NC-7)	Mr. Mark J. Millard mjmillar@astate.edu	Improved populations and synthetics	United States	804	804	
				Antigua and Barbuda	1		1
				Argentina	1		1
				Australia	1		1
				Barbados	2		2
				Brazil	19		19
				Bulgaria	7		7
				Cameroon	5		5
				Canada	38		38
				China	77		77
				Colombia	7		7
				Costa Rica	14		14
				Croatia	29		29
				Cuba	6		6
				Dominican Republic	4		4
				El Salvador	6		6
				Finland	1		1
				Former Soviet Union	35		35
				Germany	2		2
				Grenada	2		2
				Guadeloupe	4		4
				Guatemala	15		15
				Haiti	6		6
				Honduras	10		10
				Hungary	5		5
				India	1		1
				Indonesia	1		1
				Israel	9		9
				Jamaica	1		1
				Japan	1		1
				Kazakhstan	1		1
				Kenya	36		36
				Mauritius	1		1
				Mexico	123		123
				Moldova	4		4
				Netherlands	1		1
				New Zealand	4		4
				Nicaragua	9		9
				Nigeria	5		5
				Panama	11		11
				Paraguay	2		2
				Peru	1		1
				Philippines	1		1
				Poland	4		4
				Puerto Rico	21		21
				Reunion	1		1
				Romania	4		4
				Russian Federation	8		8
				South Africa	4		4
				St. Lucia	1		1
				St. Vincent and Grenadines	4		4
Taiwan	6		6				
Tanzania	6		6				
Thailand	3		3				
Trinidad and Tobago	4		4				
Ukraine	7		7				
Venezuela	3		3				
Vietnam	1		1				
Virgin Islands (U.S.)	2		2				
Zambia	1		1				
Total	1,393	804	589				
			Inbreds	United States	1,480	1,480	
				Argentina	29		29
				Australia	8		8
				Brazil	1		1
				Cameroon	45		45
				Canada	57		57
				China	48		48
				CIMMYT	80		80
				Former Soviet Union	11		11
				France	13		13
				Hungary	15		15
				India	6		6
				Israel	19		19
				Netherlands	4		4
				Nigeria	49		49
				Philippines	3		3
				Poland	34		34
				Portugal	3		3
				Reunion	1		1
				Romania	14		14
				South Africa	72		72
Spain	17		17				
Taiwan	4		4				
Thailand	8		8				
Ukraine	2		2				
Uruguay	16		16				
Total	2,039	1,480	559				
			Teosinte	Guatemala	22		22
				Honduras	2		2
				Mexico	169		169
				Nicaragua	1		1
				Unknown	45		45
Total	239	0	239				
GRAND TOTAL				18,402	3,604	14,798	
Venezuela	Inst. Nac. de Invest. Agrí. (INIA-CENIAP)	Victor Segovia vsegovia@inia.gov.ve	Landraces	Venezuela	1,197	1,197	
				Total	1,197	1,197	0
			Improved populations and synthetics	Venezuela	289	289	
				México	183		183
				Total	472	289	183
			Open pollinated varieties	Venezuela	48	48	
				Total	48	48	0
			Inbreds	Venezuela	3,000	3,000	
				México	40		40
				Total	3,040	3,000	40
GRAND TOTAL				4,757	4,534	223	

Country	Institution	Collection Manager data	Accession category		No. of accessions	No. of introductions	
			Type accession	Country of origin		Own country	Other countries
Yugoslavia	Maize Research Institute "Zemun Polje"	Drazen Jelovac djelovac@mriizp.co.yu	Landraces	Yugoslavia	1,238	1,238	
				Alghanistan	2		2
				Angola	16		16
				Austria	11		11
				Bolivia	1		1
				Bosnia and Herzegovina	323		323
				Brazil	3		3
				Bulgaria	74		74
				Canada	22		22
				China	19		19
				Croatia	285		285
				Czechoslovakia	241		241
				Democratic People's Republic	3		3
				Ethiopia	2		2
				France	23		23
				German Democratic Republic	48		48
				Germany	1		1
				Greece	68		68
				Hungary	18		18
				India	2		2
				Iran	88		88
				Israel	2		2
				Italy	76		76
				Jamaica	1		1
				Kenya	4		4
				Macedonia, Former Yugoslav	221		221
				Mexico	24		24
				Morocco	6		6
				Netherlands	5		5
				Pakistan	186		186
				Poland	8		8
				Portugal	42		42
				Romania	49		49
				Slovenia	106		106
				South Africa	6		6
Spain	2		2				
Sudan	4		4				
Tanzania	3		3				
Thailand	1		1				
Turkey	1,101		1,101				
URSS	230		230				
Uruguay	3		3				
USA	27		27				
Yugoslavia	1,238		1,238				
Total	5,833		1,238	4,595			
			Improved populations and synthetics				
			Yugoslavia	6	6		
			Argentina	68		68	
			Brazil	1		1	
			Bulgaria	20		20	
			Canada	5		5	
			Czechoslovakia	7		7	
			Ethiopia	2		2	
			Germany	4		4	
			Hungary	5		5	
			Jordan	3		3	
			Mexico	69		69	
			Nepal	2		2	
			Netherlands	5		5	
			Poland	4		4	
			Romania	5		5	
			Spain	1		1	
			URSS	17		17	
			USA	93		93	
			Zimbabwe	4		4	
			Total	321		6	315
			Inbreds				
			Yugoslavia	134	134		
			Alghanistan	2		2	
			Argentina	5		5	
			Australia	2		2	
			Austria	2		2	
			Bulgaria	286		286	
			Canada	60		60	
			China	20		20	
			Czechoslovakia	779		779	
			Democratic People's Republic	26		26	
			France	61		61	
			German Democratic Republic	49		49	
			Greece	122		122	
			Hungary	67		67	
			India	1		1	
			Iran	64		64	
			Italy	20		20	
			Mexico	54		54	
			Netherlands	10		10	
			Pakistan	14		14	
			Poland	110		110	
			Portugal	4		4	
			Romania	58		58	
			Spain	5		5	
			Switzerland	14		14	
			Turkey	406		406	
			URSS	684		684	
			USA	288		288	
			Total	3,347		134	3,213
			Unknown				
			Yugoslavia	8	8		
			Austria	1		1	
			Bolivia	1		1	
			Canada	6		6	
			Czechoslovakia	1		1	
			France	276		276	
			Germany	17		17	
			Greece	203		203	
			Hungary	1		1	
			Israel	1		1	
			Italy	563		563	
			Japan	2		2	
			Mexico	25		25	
			Netherlands	7		7	
			Pakistan	9		9	
			Peru	2		2	
			Portugal	1		1	
			Spain	950		950	
			Turkey	2		2	
			URSS	8		8	
			USA	17		17	
			Total	2,101		8	2,093
			GRAND TOTAL	11,602		1,386	10,216

APPENDIX 7: Summary of the questionnaire on maize collections by world regions

Region	Country	Institution	Accession category	No. of accessions	No. of introductions	
					Own country	Other countries
North America	Mexico	CIMMYT, INT	Landraces	50,895	21,939	28,956
		INIFAP-Mexico	Improved populations and synthetics	2,583	1,994	589
		INIFAP-Oaxaca	Open pollinated varieties	1,117	1,117	0
	USA	NC-7	Inbreds	2,397	1,838	559
			Teosinte	563	297	266
			Tripsacum	122	91	31
GRAND TOTAL				57,677	27,276	30,401
Central America	Costa Rica	CATIE	Landraces	1,333	974	359
	Guatemala	Instituto de Ciencia y Tecnología Agrícolas (ICTA)				
GRAND TOTAL				1,333	974	359
South America	Argentina	INTA				
	Bolivia	Centro de Invest. Fitoecogenéticas de Pairumani				
	Brazil	Embrapa Milho e Sorgo	Landraces	18,877	16,383	2,494
	Chile	Instituto de Investigaciones Agropecuarias	Improved populations and synthetics	691	691	0
	Colombia	CORPOICA	Open pollinated varieties	66	48	18
	Ecuador	INIAP-DENAREF	Inbreds	1,992	1,972	20
	Paraguay	CRIA	Teosinte	7	0	7
	Peru	Universidad Nacional Agraria La Molina	Tripsacum	1	0	1
	Uruguay	INIA				
	Venezuela	Inst. Nac. de Invest. Agrí.(INIA-CENIAP)				
GRAND TOTAL				21,634	19,094	2,540
Europe	Austria	Austrian Agency for Health and Food Safety				
	Czech Republic	RICP Prague-Ruzyne				
		Research Institute of Crop Production of Prague				
	France	Inst. Nat. de la Recherche Agronomique				
	Georgia	Non specified				
	Netherlands	Centre for Genetic Resources the Netherlands				
	Romania	Agricultural Research and Development Institute Suceava Genebank				
		Agricultural Research and Station TURDA	Landraces	14,921	8,548	6,373
	Slovak Republic	Gene Bank, Research Inst.of Plant Production	Improved populations and synthetics	2,621	1,294	1,327
	Spain	Misión Biológica de Galicia (CSIC)	Open pollinated varieties	708	432	276
	Sweden	Nordic Gene Bank	Inbreds	13,698	5,329	8,369
	Turkey	Aegean Agricultural Research Institute	Population type unknown	172	10	162
	Ukraine	NCPGRU	Unknown	2,101	8	2,093
	Yugoslavia	Maize Research Institute "Zemun Polje"				
GRAND TOTAL				34,221	15,621	18,600
Asia	China	Institute of Crop Science, C A A S	Landraces	18,171	16,086	2,085
	India	National Bureau of Plant Genetic Resources	Improved populations and synthetics	855	321	534
	Indonesia	ICABIOGRAD	Open pollinated varieties	428	350	78
	Pakistan	Plant Genetic Resources Programme Nat. Agric. Res. Center	Inbreds	4,243	2,911	1,332
	Sri Lanka	Plant Genetic Resources Centre	Teosinte	3	0	3
	Thailand	National Corn and Sorghum Research Center, Kasetsart Univ.				
GRAND TOTAL				23,700	19,668	4,032
Africa	Kenya	Kenya Agricultural Research Inst. Nat. Genebank of Kenya	Landraces	1,892	11	1881
	Nigeria	IITA	Improved populations and synthetics	38	4	34
			Inbreds	74	74	0
GRAND TOTAL				2,004	89	1,915
Oceania	Australia	Australian Tropical Crops & Forages Germplasm Collection	Landraces	103	0	103
			Improved populations and synthetics	102	76	26
			Open pollinated varieties	95	20	75
			Inbreds	409	90	319
			GRAND TOTAL			

APPENDIX 8: Summary of the questionnaire on seed storage conditions

Country	Institution	Seed storage category	Storage temp. (°C)	Storage humidity (% RH)	Type of container	Initial storage quantity	Seed viability (%)	Storage size (m ²)
Argentina	INTA	Long-term collection (30+ years)	-18	not controlled (6% seed moisture)	Aluminum foil	0.5 - 1 kg	> 85%	189
		Medium-term collection (until 30 years)	***	***	***	***	***	***
		Short-term collection (until 10 years)	4 - 7	not controlled (6-8% seed moisture)	Aluminum foil	1.5 - 3 kg	> 85%	150
Australia	Australian Tropical Crops & Forages Germplasm Collection	Long-term collection (30+ years)	-20	15	Aluminum foil	2000 - 4000	90%	4
		Medium-term collection (until 30 years)	NS*	NS*	NS*	NS*	NS*	NS*
		* Non specified	Short-term collection (until 10 years)	NS*	NS*	NS*	NS*	NS*
Austria	Austrian Agency for Health and Food Safety	Long-term collection (30+ years)	-20	(20 - RH) 6% moisture	Sealed glass-jars	***	> 80	48
		Medium-term collection (until 30 years)	10 - 15	(25 - RH) 6% moisture	Glass jars	***	> 80	120
		Short-term collection (until 10 years)	***	***	***	***	***	***
Bolivia	Centro de Invest. Fitoecogenéticas de Pairumani	Long-term collection (30+ years)	NS*	NS*	NS*	NS*	NS*	NS*
		Medium-term collection (until 30 years)	NS*	NS*	NS*	NS*	NS*	NS*
		* Non specified	Short-term collection (until 10 years)	NS*	NS*	NS*	NS*	NS*
Brazil	Embrapa Milho e Sorgo	Long-term collection (30+ years)	***	***	***	***	***	***
		Medium-term collection (until 30 years)	8 - 10	0.3	Cotton bags	at least 2 Kg after the 1 st multiplication	85 - 100%	135
		Short-term collection (until 10 years)	***	***	***	***	***	***
Chile	Instituto de Investigaciones Agropecuarias	Long-term collection (30+ years)	-18	0.15	Plastic container	2000 Seeds	OVER 75 %	
		Medium-term collection (until 30 years)	-5 - 0	0.45	Plastic container	2000 Seeds	OVER 75 %	59.85
		Short-term collection (until 10 years)	5 - 10	0.45	Plastic container	2000 Seeds	OVER 75 %	59.85
China	Institute of Crop Science, C A A S	Long-term collection (30+ years)	-18	≤50% (6-8% seed moisture)	Aluminum foil	300g	85 - 100%	1440
		Medium-term collection (until 30 years)	-4	≤50% (6-8% seed moisture)	Aluminum foil	1kg	85 - 100%	8160
		Short-term collection (until 10 years)	***	***	***	***	***	***
Colombia	CORPOICA	Long-term collection (30+ years)	-20	not controlled (10-13% seed moisture)	Plastic-aluminum foil	1500 seeds	85-100%	60
		Medium-term collection (until 30 years)	***	***	***	***	***	***
		Short-term collection (until 10 years)	4	not controlled (10-13% seed moisture)	Plastic-aluminum foil	1500 seeds	85-100%	90
Costa Rica	CATIE	Long-term collection (30+ years)	***	***	***	***	***	***
		Medium-term collection (until 30 years)	5	90	Aluminum foil	58 63	38%	40
		Short-term collection (until 10 years)	***	***	***	***	***	***
Czech Republic	RICP Prague-Ruzyně	Long-term collection (30+ years)	-18	4 - 5	Glass jars	NS*	NS*	300
		Medium-term collection (until 30 years)	-5	4 - 5	Glass jars	NS*	NS*	NS*
		* Non specified	Short-term collection (until 10 years)	5	4 - 5	Glass jars	NS*	NS*
Czech Republic	Research Institute of Crop Production of Prague	Long-term collection (30+ years)	-18	7 - 8 %	Glass jars	50 - 250 g	≥ 80 %	0.5
		Medium-term collection (until 30 years)	-5	7 - 8 %	Glass jars	50 - 250 g	≥ 80 %	1.5
		Short-term collection (until 10 years)	***	***	***	***	***	***
Ecuador	INIAP-DENAREF	Long-term collection (30+ years)	-15	***	Aluminum foil bags	1000	over 85%	30
		Medium-term collection (until 30 years)	-15	***	Aluminum foil bags	1000	over 85%	20
		Short-term collection (until 10 years)	8	not controlled (78%)	Air-tight, plastic	3 Kg	over 90%	53
France	Inst. Nat. de la Recherche Agronomique	Long-term collection (30+ years)	-18°C	not controlled	aluminum foil	2 bags in 2 different storage places	90%	10
		Medium-term collection (until 30 years)	6°C	0.3	aluminum foil	12 bags/600 kernels per population	90%	150
		Short-term collection (until 10 years)	6°C	0.3	tissue bags	» 3kg	90%	150
Georgia	Non specified	Long-term collection (30+ years)	***	***	***	***	***	***
		Medium-term collection (until 30 years)	***	***	***	***	***	***
		* Non specified	Short-term collection (until 10 years)	40	NS*	Glass jars	NS*	NS*

Country	Institution	Seed storage category	Storage temp. (°C)	Storage humidity (% RH)	Type of container	Initial storage quantity	Seed viability (%)	Storage size (m ²)
Guatemala	Instituto de Ciencia y Tecnología Agrícolas (ICTA)	Long-term collection (30+ years)	NS*	NS*	NS*	NS*	NS*	NS*
		Medium-term collection (until 30 years)	NS*	NS*	NS*	NS*	NS*	NS*
		Short-term collection (until 10 years)	NS*	NS*	NS*	NS*	NS*	NS*
* Non specified								
India	National Bureau of Plant Genetic Resources	Long-term collection (30+ years)	NS*	NS*	NS*	NS*	NS*	NS*
		Medium-term collection (until 30 years)	NS*	NS*	NS*	NS*	NS*	NS*
		Short-term collection (until 10 years)	NS*	NS*	NS*	NS*	NS*	NS*
* Non specified								
Indonesia	ICABIOGRAD	Long-term collection (30+ years)	NS*	NS*	NS*	NS*	NS*	NS*
		Medium-term collection (until 30 years)	NS*	NS*	NS*	NS*	NS*	NS*
		Short-term collection (until 10 years)	NS*	NS*	NS*	NS*	NS*	NS*
* Non specified								
Kenya	Kenya Agricultural Research Inst. Nat. Genebank of Kenya	Long-term collection (30+ years)	-20	18-20	Aluminium foil	At least 2,000 seeds	At least 85%	75
		Medium-term collection (until 30 years)	5	18-20	Aluminium foil	At least 2,000 seeds	At least 85%	75
		Short-term collection (until 10 years)	***	***	***	***	***	***
Mexico	CIMMYT, INT	Long-term collection (30+ years)	-18	not controlled (6-8% seed moisture)	Aluminum foil	1 - 2kg	85 - 100%	400
		Medium-term collection (until 30 years)	-3	25 - 30%	Air-tight, plastic	2 - 3kg	85 - 100%	400
		Short-term collection (until 10 years)	***	***	***	***	***	***
Mexico	INIFAP - Mexico	Long-term collection (30+ years)	-20	15 - 20	Aluminum foil	500	90%	45.3
		Medium-term collection (until 30 years)	0 - 5	45	Aluminum foil & glass	1000 seeds	80%	168
		Short-term collection (until 10 years)	environment	environment	papers	500	60 - 70	400
Mexico	INIFAP - Oaxaca	Long-term collection (30+ years)	***	***	***	***	***	***
		Medium-term collection (until 30 years)	***	***	***	***	***	***
		Short-term collection (until 10 years)	4	40	Plastic boxes	300 - 3000 g	>70	64
Netherland	Centre for Genetic Resources the Netherlands	Long-term collection (30+ years)	-20	not controlled	Aluminium foil	2000	> = 80%	3
		Medium-term collection (until 30 years)	4	not controlled	Aluminium foil	600	initial > = 80%	2
		Short-term collection (until 10 years)	***	***	***	***	***	***
Nigeria	IITA	Long-term collection (30+ years)	-20	not applicable	Aluminium foil	250 seeds	70-100%	483
		Medium-term collection (until 30 years)	***	***	***	***	***	***
		Short-term collection (until 10 years)	5	25	Plastic Jar	variable	70-100%	755
Pakistan	Plant Genetic Resources Programme Nat. Agric. Res. Center	Long-term collection (30+ years)	-20	NS*	Aluminum foil	20 gram	Above 90%	NS*
		Medium-term collection (until 30 years)	5	NS*	Aluminum foil	200 g	Above 90%	NS*
		Short-term collection (until 10 years)	10	NS*	Plastic bottle	500 g	Above 90%	NS*
* Non specified								
Paraguay	CRIA	Long-term collection (30+ years)	NS*	NS*	NS*	NS*	NS*	NS*
		Medium-term collection (until 30 years)	NS*	NS*	NS*	NS*	NS*	NS*
		Short-term collection (until 10 years)	NS*	NS*	NS*	NS*	NS*	NS*
* Non specified								
Peru	Universidad Nacional Agraria La Molina	Long-term collection (30+ years)	***	***	***	***	***	***
		Medium-term collection (until 30 years)	***	***	***	***	***	***
		Short-term collection (until 10 years)	5 - 10	40	Glass & cans	1 - 10 kg	60%	168
Romania	Agricultural Research and Development Institute	Long-term collection (30+ years)	-18	NS*	NS*	NS*	NS*	NS*
		Medium-term collection (until 30 years)	-3	~75 - 80%	NS*	500 grams	>85%	NS*
		Short-term collection (until 10 years)	4	0.75	NS*	NS*	NS*	NS*
* Non specified								
Romania	Suceava Genebank	Long-term collection (30+ years)	-20	not controlled (5% seed moisture)	Aluminum foil	600 seeds	85 - 100%	85
		Medium-term collection (until 30 years)	4	not controlled (6-8% seed moisture)	Glass jars	700 - 10000 seeds	85 - 100%	303
		Short-term collection (until 10 years)	***	***	***	***	***	***
Romania	Agricultural Research and Station TURDA	Long-term collection (30+ years)	***	***	***	***	***	***
		Medium-term collection (until 30 years)	***	***	***	***	***	***
		Short-term collection (until 10 years)	10	30 - 40%	Plastic / metal boxes	1 - 3kg	80 - 100%	200
Slovak Republic	Gene Bank, Research Inst of Plant Production	Long-term collection (30+ years)	-17	5 - 6%	Glass jars	NS*	80 - 100%	NS*
		Medium-term collection (until 30 years)	4	NS*	Glass jars	NS*	80 - 100%	NS*
		Short-term collection (until 10 years)	***	***	***	***	***	***
* Non specified								
Spain	Misión Biológica de Galicia (CSIC)	Long-term collection (30+ years)	***	***	***	***	***	***
		Medium-term collection (until 30 years)	***	***	***	***	***	***
		Short-term collection (until 10 years)	2	65	Paper envelopes	1000 Seed	70	80
Sri Lanka	Plant Genetic Resources Centre	Long-term collection (30+ years)	***	***	***	***	***	***
		Medium-term collection (until 30 years)	1	0.25	Tin cans	150g	85%	NS*
		Short-term collection (until 10 years)	5	0.25	Aluminium foil	600g	0.85	NS*
* Non specified								
Sweden	Nordic Gene Bank	Long-term collection (30+ years)	-18	NS*	Aluminum foil	NS*	85 - 100%	NS*
		Medium-term collection (until 30 years)	-18	NS*	Aluminum foil	NS*	85 - 100%	NS*
		Short-term collection (until 10 years)	***	***	***	***	***	***
* Non specified								

Country	Institution	Seed storage category	Storage temp. (°C)	Storage humidity (% RH)	Type of container	Initial storage quantity	Seed viability (%)	Storage size (m ³)
Sweden	Nordic Gene Bank	Long-term collection (30+ years)	-18	NS*	Aluminum foil	NS*	85 - 100%	NS*
		Medium-term collection (until 30 years)	-18	NS*	Aluminum foil	NS*	85 - 100%	NS*
		Short-term collection (until 10 years)	***	***	***	***	***	***
* Non specified								
Thailand	National Corn and Sorghum Research Center, Kasetsart Univ.	Long-term collection (30+ years)	***	***	***	***	***	***
		Medium-term collection (until 30 years)	***	***	***	***	***	***
		Short-term collection (until 10 years)	5	60 - 70%	Plastic bottle	0.5 - 1kg	80 - 100%	35
Turkey	Aegean Agricultural Research Institute	Long-term collection (30+ years)	-18	not controlled	Aluminium foil	Variable	80 - 100%	191
		Medium-term collection (until 30 years)	0	not controlled	Aluminium foil	Variable	80 - 100%	268
		Short-term collection (until 10 years)	4	not controlled	Aluminium foil	Variable	90 - 100%	41
Ukraine	NCPGRU	Long-term collection (30+ years)	NS*	NS*	NS*	NS*	NS*	NS*
		Medium-term collection (until 30 years)	NS*	NS*	NS*	NS*	NS*	NS*
		Short-term collection (until 10 years)	NS*	NS*	NS*	NS*	NS*	NS*
* Non specified								
Uruguay	INIA	Long-term collection (30+ years)	-20	NS*	Aluminum foil	NS*	NS*	NS*
		Medium-term collection (until 30 years)	-20	NS*	Aluminum foil	NS*	NS*	NS*
		Short-term collection (until 10 years)	-20	NS*	NS*	NS*	NS*	NS*
* Non specified								
USA	North Central Regional Plant Introduction Station, ARS, USDA	Long-term collection (30+ years)	***	***	***	***	***	***
		Medium-term collection (until 30 years)	4	0.25	Plastic jars (3.8 liters)	20,000 Seeds	85 - 100%	
		Short-term collection (until 10 years)	***	***	***	***	***	***
Venezuela	Inst. Nac. de Invest. Agrí. (INIA-CENIAP)	Long-term collection (30+ years)	-18	0.65	Aluminum foil	1200	0.85	400
		Medium-term collection (until 30 years)	5	45	Glass jars	1200	0.85	500
		Short-term collection (until 10 years)	16	45	Metal cans	3000	85	100
* Non specified								
Yugoslavia	Maize Research Institute "Zemun Polje"	Long-term collection (30+ years)	NS*	NS*	NS*	NS*	NS*	NS*
		Medium-term collection (until 30 years)	NS*	NS*	NS*	NS*	NS*	NS*
		Short-term collection (until 10 years)	NS*	NS*	NS*	NS*	NS*	NS*
* Non specified								

APPENDIX 9: Summary of the questionnaire on seed exchange policy and information databases

Country	Institution	Seed exchange function	Handling seed requests/shippments	Seed inventory/paperwork
Argentina	INTA	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>Used (x) Not used ()</p> <p>Collection manager (x) Other* (): MSc. Marcelo Edmundo Ferrer</p> <p>Yes³ (x) No () If yes, where: Base Bank Castelar Argentina, CIMMYT, NCGRP Fort Collins (EEUU)</p> <p>Seed accessions available(x) Not available (x) ciertos materiales no están disponibles No.: 1300</p> <p>Number or weight (g): 100 - 150 seeds</p> <p>Free (x) Charge (x) private institutions may be charged Free (x) Charge (x) Private institutions may be charged</p> <p>Used (x) Not used ()</p>	<p>Updated (x) Not updated ()</p> <p>MLS (x) Bilateral (x) Other () specify: Se utilizará MLS cuando Argentina Ratifique el Tratado</p>
Australia	Australian Tropical Crops & Forages Germplasm Collection	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>Used (√) Not used ()</p> <p>Collection manager (√) Other* (): Peter Lawrence</p> <p>Yes³ () No (√) If yes, where:</p> <p>Seed accessions available(√) Not available () No.: all (103)</p> <p>Number or weight (g):</p> <p>Free (√) Charge () Free (√) Charge ()</p> <p>Used () Not used (√)</p>	<p>Updated (√) Not updated ()</p> <p>MLS (√) Bilateral () Other () specify:</p>
Austria	Austrian Agency for Health and Food Safety	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>Used (x) Not used ()</p> <p>Collection manager (x) Other* (): Paul Freudenthaler Dipl. Ing., Head Wolfgang Kalnz Ing., Curator</p> <p>Yes³ () No (x) If yes, where:</p> <p>Seed accessions available (x) Not available () No.: 21</p> <p>Number or weight (g): 10 g</p> <p>Free (x) Charge () Free () Charge (x)</p> <p>Used (x) Not used ()</p>	<p>Updated (x) Not updated ()</p> <p>MLS (x) Bilateral () Other () specify:</p>
Bolivia	Centro de Invest. Fitogenéticas de Pairumani	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment</p> <p>MTA used/required</p>	<p>Used (x) Not used ()</p> <p>Collection manager () Other* (x):Tha director of the center Gonzalo Avila, Director</p> <p>Yes³ (x) No () If yes, where: CIMMYT and NSSL</p> <p>Seed accessions available() Not available (x)</p> <p>Used (x) Not used ()</p>	<p>Updated (x) Not updated ()</p> <p>Bolivia not yet signen the International Treaty on Plant Genetic Resources for Food and Agriculture</p>
Brazil	Embrapa Milho e Sorgo	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>Used (X) Not used () Passport data</p> <p>Collection manager () Other* (X): Dr. Ivan Cruz - General Manager of Embrapa Maize and Sorghum</p> <p>Yes³ (X) No () If yes, where: Embrapa Genetic Resources and Biotechnology and CIMMYT</p> <p>Seed accessions available(X) Not available () No.: 3285 (Landraces, except Indigenouse varieties, composites from lai)</p> <p>Number or weight (g): 100-200 seeds (60-100g)</p> <p>Free (X) Charge () Free (X) Charge ()</p> <p>Used (X) Not used ()</p>	<p>Updated (X) Not updated ()</p> <p>MLS () Bilateral () Other (X) specify: A MTA is required and follow a template for all the requests</p>
Chile	Instituto de Investigaciones Agropecuarias	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>Used X Not used ()</p> <p>Collection manager X Other* X: ERIKA SALAZAR / HEAD GENETIC RESOURCES UNIT LA PLATINA IVETTE SEGUEL / COORDINATOR INIA'S NATIONAL GENETIC RESOURCES PROGRAM</p> <p>Yes³ X No X If yes, where: BASE BANK OF CHILE, CIMMYT AND NCGRP</p> <p>Seed accessions available (X) Not available No.: NOT DEFINED</p> <p>Number or weight (g): 50 SEEDS</p> <p>Free () Charge () NOT DEFINED Free () Charge () NOT DEFINED</p> <p>Used X Not used ()</p>	<p>Updated X Not updated X</p> <p>MLS () Bilateral () Other () specify:</p>
China	Institute of Crop Science , C A A S	<p>NON SPECIFIED DATAS</p>		
Colombia	CORPOICA	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>Used () Not used (X)</p> <p>Collection manager () Other* (X): MINISTERIO DEL MEDIO AMBIENTE-MINISTERIO DE AGRICULTURA INSTITUTO COLOMBIANO AGROPECUARIO-ICA</p> <p>Yes³ (x) No () If yes, where: NCGRP, Fort Collins Co. USA .</p> <p>Seed accessions available() Not available (X)</p> <p>Free () Charge () Free () Charge ():</p> <p>Used (x) Not used ():</p>	<p>Updated () Not updated (X)</p> <p>Safety duplicates at NCGRP is about 90%</p>
Costa Rica	CATIE	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>Used (X) Not used ()</p> <p>Collection manager () Other* (X): Head, PGR group Andreas Ebert, Head, PGR group</p> <p>Yes³ () No (X) If yes, where:</p> <p>Seed accessions available() Not available (X) No.: original samples have not been regenerated yet</p> <p>Number or weight (g):</p> <p>Free (X) Charge () Free () Charge (X)</p> <p>Used (X) Not used ()</p>	<p>Updated (X) Not updated ()</p> <p>MLS (X) Bilateral () Other () specify:</p>

Country	Institution	Seed exchange function	Handling seed requests/shipments	Seed inventory/paperwork
Czech Republic	RICP Prague-Ruzyně	An accession database Who authorizes the shipment? Name 1 and title: Name 2 and title: Are accessions duplicated elsewhere Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment MTA used/required	Used (x) Not used () Collection manager (x) Other* (): Vera Chytilova Yes ² () No (x) If yes, where: Seed accessions available(x) Not available () No: Number or weight (g) about 100 seeds Free (x) Charge () Free (x) Charge () Used (x) Not used ()	Updated () Not updated () MLS () Bilateral () Other () specify:
Czech Republic	Research Institute of Crop Production of Prague	An accession database Who authorizes the shipment? Name 1 and title: Name 2 and title: Are accessions duplicated elsewhere Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment MTA used/required	Used (x) Not used () Collection manager (X) Other* (X): Head of gene bank Zdenek Stehno Yes ² (partially) No () If yes, where: RIPP Plestany, Slovakia Seed accessions available(X) Not available () No: 95 Number or weight (g): 50 seeds maximum Free (X) Charge () Free (X) Charge () Used (X) Not used ()	Updated (X) Not updated () MLS (X) Bilateral () Other () specify:
Ecuador	INIAP-DENAREF	An accession database Who authorizes the shipment? Name 1 and title: Name 2 and title: Are accessions duplicated elsewhere Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment MTA used/required	Used (x) Not used () Collection manager (x) Other* (x): Dr. Julio Cesar Delgado (Director INIAP) Ing. Abel Viteri Echanique (Director SESA) Yes ² (x) No () If yes, where: CIMMYT Seed accessions available(x) Not available () No.: 500 Number or weight (g): 100 Free (x) Charge () Free () Charge (x) Used (x) Not used ()	Updated (x) Not updated () MLS (x) Bilateral () Other () specify:
France	Inst. Nat. de la Recherche Agronomique	An accession database * There is 3 different databases: Who authorizes the shipment? Name 1 and title: Name 2 and title: Are accessions duplicated elsewhere Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment MTA used/required	Used (x) Not used () The database Collection manager (x) Other* (): Anne ZANETTO Yes ² (x) No () If yes, where: INRA and commercial freezers Seed accessions available(x) Not available () No.: 558 Number or weight (g): 600 kernels for populations 50 kernels for lines Free (x) Charge () Free (x) Charge () Used (x) Not used ()	Updated (x) Not updated () MLS () Bilateral () Other () specify: French network and more or less on the MLS
Georgia	Non specified	An accession database Who authorizes the shipment? Name 1 and title: Name 2 and title: Are accessions duplicated elsewhere Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment MTA used/required	Used (X) Not used () Passport data Collection manager (X) Other* (): Zurab Jinjkhadze - Charge of Maize collection at the Institute Tinatin Koechadze „Maize Curator in PGR Genebank Yes ² () No (X) If yes, where: Seed accessions available() Not available () No: Number or weight (g): Free () Charge () Free () Charge () Used () Not used (X)	Updated (X) Not updated () MLS () Bilateral () Other () specify:
Guatemala	Instituto de Ciencia y Tecnología Agrícolas (ICTA)	NON SPECIFIED DATAS		
India	National Bureau of Plant Genetic Resources	An accession database Who authorizes the shipment? Name 1 and title: Name 2 and title: Are accessions duplicated elsewhere Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment MTA used/required	Used (√) Not used () Collection manager () Other* (√): Director, NBPGR Secretary, Department of Agriculture Research and Education Yes ² () No () If yes, where: Seed accessions available(5855) Not available () No.: 1285 Number or weight (g): 50acc., 5g Free (√) Charge () Free (√) Charge () Used (√) Not used ()	Updated (√) Not updated () MLS (√) Bilateral () Other () specify:
Indonesia	ICABIOGRAD	NON SPECIFIED DATAS		
Kenya	Kenya Agricultural Research Inst. Nat. Genebank of Kenya	An accession database Who authorizes the shipment? Name 1 and title: Name 2 and title: Are accessions duplicated elsewhere Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment MTA used/required	Used (x) Not used () Collection manager (x) Other* (): Mr. Z.K. Muthamia Yes ² () No (x) If yes, where: Seed accessions available() Not available () No.: 1,116 Number or weight (g): 20-100 seeds Free (x) Charge () Free () Charge (x) Used (x) Not used ()	Updated (x) Not updated () MLS () Bilateral (x) Other () specify:

Country	Institution	Seed exchange function	Handling seed requests/shipments	Seed inventory/paperwork
Mexico	CIMMYT, INT	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>Used (x) Not used ()</p> <p>Collection manager (x) Other* (): Dr. Suketoshi Taba</p> <p>Yes² (x) No () If yes, where: NCGRP, Fort Collins Co. USA and the r Safety duplicates at NCGRP is about 90%</p> <p>Seed accessions available(x) Not available () Seed requests are honored by seed availability and FAO's joint statement on the designated germplasm. No. 25,457 (landrace, CIMMYT derived acc. several Teosinte acc. several Tripsacum acc.)</p> <p>Number or weight (g): 100 seeds (30-50g) 10-50 seeds available for wild species and inbreds</p> <p>Free (x) Charge () Free (x) Charge (x) Private institutions usually charged</p> <p>Used (x) Not used (); MTA for designated (in-trust collection: landrace MLS (x) Bilateral () Other () specify:</p>	<p>Updated (x) Not updated ()</p>
Mexico	INIFAP - Mexico	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of landrace accessions for which seed are available upon request: - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>used (X) not used ()</p> <p>Collection manager () other* (X): Dr. Pedro Brajčich Gallegos, Director del INIFAP</p> <p>Yes² (X) no () If yes, where: CIMMYT</p> <p>seed accessions available(X) not available () by policy Nº. (5000 accesiones de landrace)</p> <p>number or weight (g): 100 semillas</p> <p>free (X) charged () free (X) charged ()</p> <p>used (X) not used ()</p> <p>MLS (X) bilateral () Other () specify:</p>	<p>updated (X) not updated ()</p>
Mexico	INIFAP - Oaxaca	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>Used (X) Not used ()</p> <p>Collection manager () Other* (X): Dr. Eduardo Garrido Ramirez, Director Regional del Centro de Investigación Regional del Pacifico Sur, INIFAP</p> <p>Yes² (X) No () If yes, where: CIMMYT e INIFAP</p> <p>Seed accessions available(X) Not available () No. 1000</p> <p>Number or weight (g): 100 semillas para colecciones originales. En materiales sobresalientes puede proporcionarse 500 gr</p> <p>Free (X) Charge () Free () Charge (X)</p> <p>Used (X) Not used ()</p> <p>MLS (X) Bilateral () Other () specify:</p>	<p>Updated (X) Not updated ()</p>
Netherland	Centre for Genetic Resources the Netherlands	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>Used (X) Not used ()</p> <p>Collection manager (X) Other* (): Drs. Noor Bas, curator Dr. Chris Kik, Headcurator</p> <p>Yes² (X) No () If yes, where: DEU271, Genebank, Inst. for Plant Gen. & Crop Plant Res. (IPK), Malchow, Germany</p> <p>Seed accessions available(x) Not available () No. all accessions: 285</p> <p>Number or weight (g): 100 seeds</p> <p>Free (X) Charge () Free (X) Charge ()</p> <p>Used (X) Not used ()</p> <p>MLS (X) Bilateral () Other () specify:</p>	<p>Updated (X) Not updated ()</p>
Nigeria	IITA	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>Used (x) Not used ()</p> <p>Collection manager (=interim Curator) Other* (): Dumet Dominique Interim genebank curator</p> <p>Yes² (x) No () If yes, where: Some are in CIMMYT already</p> <p>Seed accessions available() Not available () No. Inventory/Rejuvenation is presently performed</p> <p>Number or weight (g): 30 to 100 seeds depending on availability. Exact number of available accessions not yet known</p> <p>Free (x) Charge () Free (x) Charge ()</p> <p>Used (x) Not used ()</p> <p>MLS (x) Bilateral () Other () specify:</p>	<p>Updated (x) Not updated ()</p>
Pakistan	Plant Genetic Resources Programme Nat. Agric. Res. Center	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>Used () Not used () Non specied</p> <p>Collection manager (=interim Curator) Other* (): Dr. Zahoor Ahmad, Programme Leader, PGRP, NARC Muhammad Afzal, Senior Scientific Officer, PGRP, NARC.</p> <p>Yes² () No () If yes, where: Non specied</p> <p>Seed accessions available() Not available () 507 accessions</p> <p>20 - 50 seeds</p> <p>Free (x) Charge () Free () Charge (x)</p> <p>Used (x) Not used ()</p> <p>MLS (x) Bilateral () Other () specify:</p>	<p>Updated () Not updated ()</p>
Paraguay	CRIA	NON SPECIFIED DATAS		
Peru	Universidad Nacional Agraria La Molina	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>Used (x) Not used ()</p> <p>Collection manager () Other* (x): INIEA (Instituto Nacional de Investigación y Extensión Agraria) Head of the INIEA</p> <p>Yes² (x) No () If yes, where: NSSL(USA), CIMMYT(México)</p> <p>Seed accessions available(x) Not available () No. 3,000</p> <p>Number or weight (g): 200</p> <p>Free (x) Charge () Free () Charge (x)</p> <p>Used (x) Not used ()</p> <p>MLS (x) Bilateral (x) Other () specify:</p>	<p>Updated (x) Not updated ()</p>
Romania	Agricultural Research and Development Institute	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>Used () Not used () Non specied</p> <p>Collection manager (x) Other* (): Dr. Verzea Marian</p> <p>Yes² (x) No () If yes, where: Suceava Genebank</p> <p>Seed accessions available() Not available () 234 accessions</p> <p>100 seeds</p> <p>Free () Charge (x) \$1/seed Free () Charge (x)</p> <p>Used () Not used (x)</p> <p>MLS () Bilateral () Other () specify:</p>	<p>Updated (x) Not updated ()</p>

Country	Institution	Seed exchange function	Handling seed requests/shipments	Seed inventory/paperwork
Romania	Suceava Genebank	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>Used (x) Not used ()</p> <p>Collection manager () Other* (x): Dr. Silvia Strajeru, director of Suceava Genebank</p> <p>Yes³ () No (x)</p> <p>Seed accessions available(x) Not available () No:2224 (landraces, inbreds)</p> <p>Number or weight (g): 100 seeds (30-50g) 50 seeds available for landraces, 10-50 seeds available for inbreds lines which are confidentials</p> <p>Free (x) Charge () Free (x) Charge ()</p> <p>Used (x) Not used (); MTA for designated inbred lines</p>	<p>Updated (x) Not updated ()</p> <p>MLS (x) Bilateral () Other () specify:</p>
Romania	Agricultural Research and Station TURDA	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>Not used (x)</p> <p>Collection manager (x) Other* (): Dr. ing. IOAN HAS, Director of the Agricultural Research Station Turda, Romania</p> <p>Yes³ () No (X)</p> <p>Seed accessions available (x) No. 311</p> <p>Number or weight (g): 100 seeds (30-50g)</p> <p>Free (x) Charge () Free (x)</p> <p>Used (x) Not used (); MTA for designated (in-trust collection: landrace MLS (x) Bilateral () Other () specify:</p>	<p>Not update(x)</p>
Slovak Republic	Gene Bank, Research Inst. of Plant Production	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>Used (x) Not used ()</p> <p>Collection manager (x) Other* (): Daniela Benedikova, PhD.</p> <p>Yes³ (x) No () If yes, where:</p> <p>Seed accessions available(x) Not available () No: 746</p> <p>Number or weight (g): 50-100 seeds</p> <p>Free (x) Charge () Free (x) Charge ()</p> <p>Used (x) Not used ()</p>	<p>Updated (x) Not updated ()</p> <p>safety duplication in Prague, Czech rep.</p> <p>MLS () Bilateral () Other () specify:</p>
Spain	Misión Biológica de Galicia (CSIC)	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>Used (X) Not used ()</p> <p>Collection manager (X) Other* (): Dr. Amando Ordás</p> <p>Yes³ (X) No () If yes, where: CRF (Madrid)</p> <p>Seed accessions available(X) Not available () 165 (Spanish landraces)</p> <p>Number or weight (g): 500 kernels (landraces) or 50 kernels (inbreds)</p> <p>Free (X) Charge () Free (X) Charge ()</p> <p>Used (X) Not used ()</p>	<p>Updated (X) Not updated ()</p> <p>MLS (X) Bilateral () Other () specify:</p>
Sri Lanka	Plant Genetic Resources Centre	NON SPECIFIED DATAS		
Sweden	Nordic Gene Bank	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>Used (x) Not used ()</p> <p>Collection manager (x) Other* (): Katarina Wedelsback Bladh</p> <p>Yes³ (x) No () Safety deposit Svalbard</p> <p>Seed accessions available(x) Not available () 250 seeds</p> <p>Free (x) Charge () Free (x) Charge ()</p> <p>Used (x) Not used ()</p>	<p>Updated (x) Not updated ()</p> <p>7</p> <p>MLS (x) Bilateral () Other () specify:</p>
Thailand	National Corn and Sorghum Research Center, Kasetsart Univ.	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>Used () Not used (x)</p> <p>Collection manager (x) Other* ():</p> <p>Yes³ () No (x) If yes, where:</p> <p>Seed accessions available(x) Not available () No.: improved populations</p> <p>Number or weight (g): 100-200 seeds</p> <p>Free (x) Charge () Free (x) Charge (x) private institutions usually charged</p> <p>Used () Not used (x) we will use MTA in the future.</p>	<p>Updated () Not updated (x)</p> <p>No</p> <p>MLS (x) Bilateral () Other () specify:</p>
Turkey	Aegean Agricultural Research Institute	<p>An accession database</p> <p>Who authorizes the shipment? Name 1 and title: Name 2 and title:</p> <p>Are accessions duplicated elsewhere</p> <p>Seed shipment - No. of accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment</p> <p>MTA used/required</p>	<p>Used (x) Not used ()</p> <p>Collection manager (x) Other* (Genebank Manager): Dr. A. Ertug Firat Dr. Ayfer Tan</p> <p>Yes³ (x) No () If yes, where: Partly duplicated in Central Research Institute for Field Crops (CRIFC)-Ankara</p> <p>Seed accessions available(x) Not available () Seed requests are sent depending on seed availability for distribution and the statements in Transfer Agreement Form. No.:1,587(landrace, composite varieties and, parents of hybrid varieties improved in Turkey)</p> <p>Number or weight (g): 100 seeds (30-50 gr)</p> <p>Free (x) Charge () Free (x) Charge ()</p> <p>Used (x) Not used ()</p>	<p>Updated (x) Not updated ()</p>
Ukraine	NCPGRU	NON SPECIFIED DATAS		

Country	Institution	Seed exchange function	Handling seed requests/shippments	Seed inventory/paperwork
Uruguay	INIA	An accession database Who authorizes the shipment? Name 1 and title: Name 2 and title: Are accessions duplicated elsewhere Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment MTA used/required	Used (X) Not used () Collection manager (X) Other* () : Dr. Federico Condon Yes ³ (X) No () If yes, where: INTA: many also at CIMMYT Seed accessions available () Not available (X) 852 landraces Number or weight (g): 100 seeds standard, exceptions considered Free () Charge () Free () Charge () Used () Not used ()	Updated () Not updated (X)
USA	North Central Regional Plant Introduction Station, ARS, USDA	An accession database Who authorizes the shipment? Name 1 and title: Name 2 and title: Are accessions duplicated elsewhere Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment MTA used/required	Used (X) Not used () Collection manager (X) Other* () : Mark Millard, Maize Geneticist, USDA, ARS Yes ³ (X) No () If yes, where: NCGRP, Ft. Collins, CO; many also at CIMMYT Seed accessions available (X) Not available () No: 12,000 of all types Number or weight (g): 100 seeds standard, exceptions considered Free (X) Charge () Free (X) Charge () Used () Not used (X)	Updated (X) Not updated ()
USA	NCGRP	An accession database Who authorizes the shipment? Name 1 and title: Name 2 and title: Are accessions duplicated elsewhere Seed shipment National Plant Germplasm System Safety Back-up Maize regeneration (in part from MOU & CIMMYT) Total Maize accessions at NCGRP	Used (X) Not used () - GRIN + inhouse Collection manager (X) Other* (X) : Dave Ellis, NCGRP Curator and Program Coordinator *Marck Millard, NPGS Maize Curator, Ames Iowa Yes ³ - Ames primarily, but also CIMMYT and other genebanks in other countries # Maize accessions held at NCGRP 13,621 - NPGS active collection 3710 - Genetic Stocks 175 - NCGRP only 4979 - restricted distribution (PVVP, Crop Science, Quarantine, collector) 6059 - held under MTA >21,000 49,582	Updated (X) Not updated () Available from Ames, IA Urbana Illinois Fort Collins, CO Not currently publically available from NPGS Not currently publically available from NPGS CIMMYT, NPGS, ?
Venezuela	Inst. Nac. de Invest. Agri. (INIA-CENIAP)	An accession database Who authorizes the shipment? Name 1 and title: Name 2 and title: Are accessions duplicated elsewhere Seed shipment - No. of landrace accessions for which seed are available upon request - Seed quantity available for a single routine request - Cost of seed - Cost of shipment MTA1 used/required	Used (X) Not used () Collection manager (X) Other* (X) : Victor Segovia (Curator) Prudencio Chacón (Presidente del INIA) Yes ³ (X) No () If yes, where: CIMMYT Seed accessions available (X) Not available () No: 200 Number or weight (g): 500 Free () Charge () Free () Charge (X) Used (X) Not used ()	Updated (X) Not updated ()
Yugoslavia	Maize Research Institute "Zemun Polje"	NON SPECIFIED DATAS		MLS2 (X) Bilateral () Other () specify

APPENDIX 10: Standards for medium- and long-term storage

Medium-term storage for maize is generally considered to be +5°C and relative humidity of 25%. Long-term storage is usually -20°C in hermetically sealed bags, cans or bottles. Almost as important as storage conditions are seed-handling and drying procedures prior to storage. Drying temperatures in excess of 36°C or conditions that promote fungal growth can both reduce subsequent germination significantly. The latter have a particularly severe effect on soft-kernelled flouy maize. Perhaps even more important are functioning back-up generators to cover gaps in electrical service. The quantities of seed needed per accession varies from 1 kg per accession for most accessions to 3 to 5 kg for typical or core accessions.

For an example, at CIMMYT maize bank, the seeds are dried at 10°C and 25%RH. Medium term storage is at -3°C and 25%RH; long term conservation is at -18°C. The seed moisture contents can be 6-8% in equilibrium with the drying conditions after 6-8 weeks. Seed is packed in laminated aluminum foil packets that can contain about 1 kg (1,000-2,500 seeds). The packages are hermetically sealed and two packets are prepared for regeneration using long-term conservation; one of these serves as a safety duplicate at another location. For active medium term conservation, one-gallon plastic airtight containers holding 2-3 kg (5,000-10,000 seeds) are used. No fungicides or insecticides are used for seed storage, except in cases where incoming seeds underwent seed treatment required by quarantine regulations. The first monitoring of seed viability is conducted after ten years of storage in the active collection, then after every five years as recommended by Genebank Standards (FAO/IPGRI, 1994) which is available at the website of Bioversity International (www.bioversityinternational.org). If the seed viability falls below 85% or the number of the seeds gets below 1500 in the active collection, the accession is regenerated or multiplied. The seed for regeneration is prepared from the base collection. As much as possible, 100 or more ears are used for the new set of seed.

APPENDIX 11: Acronyms used in this document

Acronym	Name
Bioversity	Bioversity International, Rome, Italy, previously IPGRI
CGIAR	Consultative Group on International Agricultural Research, Washington, DC
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo, Texcoco, Mexico
CML	CIMMYT Maize Line
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária, Brasília, DF - Brasil
GEM	Germplasm Enhancement of Maize, Ames, IA and Raleigh, NC, USA
GMO	Genetically Modified Organism
GPWG	Grass Phylogeny Working Group
GRAMENE	Comparative Grass Genomics, Cold Spring Harbor, NY, USA
GRIN	Germplasm Resources Information Network, Beltsville, MD, USA
IBPGR	International Board for Plant Genetic Resources, Replaced by Bioversity International
ICTA	Instituto de Ciencia y Tecnología Agrícolas, Barcenas, Guatemala
IRRI	International Rice Research Institute, Manila
IITA	International Institute for Tropical Agriculture, Ibadan, Nigeria
INIA	Instituto Nacional de Investigación Agraria, Lima, Peru
INIFAP	Instituto Nacional de Investigaciones Forestales y Agropecuarias, Mexico City
IPGRI	International Plant Genetic Resources Institute now Bioversity International
LAMP	Latin American Maize Project
MAIZEGDB	Maize Genetics and Genomics Database, Ames, IA, USA
MTA	Material Transfer Agreement
NAFTA	North American Free Trade Agreement
NARS	National Agricultural Research Centers
NCGRP	National Center for Genetic Resources Preservation, Ft. Collins, Colorado, USA
NCRPIS	North Central Regional Plant Introduction Station, Ames, Iowa, USA
NPGS	National Plant Germplasm System, Beltsville, MD, USA
SINGER	System-wide Information Network for Genetic Resources, Rome
SPS	Sanitary and Phytosanitary Standards
USDA-ARS	United States Department of Agriculture-Agricultural Research Service, Washington, DC
WTO	World Trade Organization, Geneva