Global Strategy for the *Ex Situ* Conservation of Oats (*Avena* spp.)

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DISCLAIMER

This document, developed with the input of a large number of experts, aims to provide a framework for the efficient and effective *ex situ* conservation of globally important collections of oats.

The Global Crop Diversity Trust (the Trust) provided support for this initiative and considers this document to be an important framework for guiding the allocation of its resources. However the Trust does not take responsibility 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 (dated January 2008) is expected to continue to evolve and be updated as and when circumstances change or new information becomes available.

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

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Abstract

Initiated by the Global Crop Diversity Trust a global crop strategy for the *ex situ* conservation of oats (*Avena* spp.) was elaborated and is described in this document. Key issues are: Which are the most important collections in the world and what is their composition? What combination of collections provides an optimum coverage of the gene pool? Which of these collections meet the eligibility principles/criteria of the Trust? What other institutions might provide conservation services (regeneration, characterisation, evaluation, documentation distribution etc)? What collaboration and partnership agreements will need to be put in place? How can the global oat strategy promote strong links to farmers, breeders and other users?

A questionnaire was made to update and broaden information on existing *Avena ex situ* collections and two expert and curator meetings were held to discuss results and recommendations. A Global Oat Diversity Network was established during the second meeting in St. Petersburg. It will be chaired by A.Diederichsen, PGRC, Canada. A steering committee was appointed consisting of I.Loskutov, N.Saidi, Z.Bulinska, Z.Zhang, M.Mackay and C.Germeier. Nordic Genebank and USDA will be invited to join. A task force was established for documentation/information, chaired by C.Germeier and another for pre-breeding, chaired by Michael Mackay.

The scientific background of evolution, distribution and use of the genus is outlined. Primary, secondary and tertiary gene pools are of different ploidy level. The native range of wild oats is the whole Mediterranean region and the Middle East including the Southern parts around the Caspian Sea. The greatest number of biological species occurs in North Africa, Southern Spain and Sicily. Tetraploid species, which form the secondary gene pool are mostly restricted in distribution and rare in nature and in collections. They occur in Algeria, Morocco, Tunisia, Spain and Sicily. Centres of diversity for the cultivated forms have been identified in Spain and Portugal (*A.strigosa*), Great Britain (*A.nuda* L. = *A.strigosa* subsp. *nudibrevis*), Ethiopia (*A.abyssinica*), Algeria and Morocco (*A.byzantina*), Iran, Georgia and Tatarstan (hulled forms of *A.sativa*), Mongolia and China (hull-less forms of *A.sativa*).

The scene of *ex situ* collections is characterised by a few very large collections with global coverage (PGRC Canada, USDA-ARS, Vavilov Institute, IPK Germany, Australian Winter Cereals Collection, and National Genebank of Kenya) and many smaller collections, some of which have a clear focus on national or regional origin or on specific targets as *A.sterilis* in the Israeli Lieberman Germplasm Collection. The collection of INRA Morocco is the most important collection in the centre of diversity for the wild *Avena* species and holds many rare and endemic species. The Chinese collection is extraordinary in keeping many Chinese landraces of naked oats (*A.sativa* subspec. *nudisativa*). More than 30 collections participated in the questionnaire. Seventeen collections have been identified as important collections, for other eleven more information would be required. Some of them are probably also of considerable importance.

It was recommended to use the Focused Identification of Germplasm Strategy (FIGS), as was presented by Michael Mackay to score the value of collections and for an analysis of gaps. This strategy is based on the hypotheses, that new and novel alleles are more likely to be found in landraces and wild relatives, and that landraces and wild relatives of cultivated species reflect the selection pressures of the environment in which they evolved. Geo-referencing of collecting data will be necessary to use this approach and will be a priority task for the information/documentation task force. Then the approach could be used to estimate the probability of finding valuable traits in the collections. FIGS will also be used to select interesting accessions to be used in the pre-breeding initiative.

Most of the collections are in good condition. Only few have insufficient coverage of the *Avena* collection by long term storage. The most urgent problem of collections is the regeneration backlog. It concerns primarily the collection parts of the wild species. The very large collections in Canada and the United States face backlogs of ten thousand and thousands of accessions respectively. Both important collections in the centre of diversity, the Moroccan and the Spanish collection are in urgent need of regeneration.

Another matter of concern is safety duplication. Several genebanks have not yet established arrangements for safety duplication. Some others have established only national or institutional arrangements. These can be sufficient in cases of physical disaster, but are of no help in case of political or economic instabilities. The Global Crop Diversity Trust offers to support safety duplication in the Svalbard facilities.

I. Introduction

a) The Global Crop Diversity Trust and the Crop Strategy

This study was initiated and supported by the Global Crop Diversity Trust. The Trust is a joint initiative of FAO and Bioversity International (Bioversity, formerly IPGRI) on behalf of the Centres of the CGIAR in public-private partnership. At its centre is an endowment fund with a target $260 million, generating about $12 million per year for *ex situ* conservation, in perpetuity, to support an efficient and effective approach to the conservation of key crop diversity collections on the long-term. This comprises the following management activities: storage and maintenance as a seed, *in vitro* or in the field, safety-duplication, regeneration, characterisation, documentation, health of germplasm, distribution and links to users.

The Trust is an essential element of the funding strategy of the International Treaty (IT). A technical framework is provided by the Global Plan of Action. The International Treaty has been negotiated during seven years from 1994-2001 to harmonize it with the Convention of Biological Diversity (CBD). It is legally binding and has to be ratified by participating countries. It creates a Multilateral System to facilitate access to plant genetic resources and a fair and equitable sharing of benefits for over 65 major crops and forages (Annex I), which should be put into free exchange. A Governing Body is made up of government representatives of the 103 countries that have ratified the Treaty. It sets out the conditions for access and benefit-sharing in a standard "Material Transfer Agreement" (SMTA). When a commercial product is developed using these resources, the Treaty provides for payment of an equitable share of the resulting monetary benefits, if this product may not be used without restriction by others for further research and breeding. If others may use it, payment is voluntary.

The following eligibility principles are essential: Co-funding by the Trust is restricted to already existing *ex situ* collections of crops listed in Annex I of the IT. They must be in the public domain, based on the ratification of the IT, and they must be accessible under the terms of the IT. Their objective must be long term conservation and they have to agree to cooperate and take advantage of synergies and a more efficient and cost effective global conservation system. Interim agreements are available in case a country has not yet signed the IT. A stepwise approach is intended, building on what already exists and concentrating on the largest and most diverse collections. Funding will be within a framework of cooperation by the collections not for collections separately. The Trust sees its role in promoting more effective and efficient conservation and securing material that might be threatened. Thereby it makes basic assumptions on effectiveness and efficiency.

The Trust intends not to build up capacities to evaluate proposals itself. Rather it seeks for expert advice (strategies), which will be used to invite collections to submit proposals. Strategies are developed at a regional level and a crop level. In the Global Crop Strategies holders of collections and other crop experts identify the most important collections for a crop, determine a model for collaboration and sharing of responsibilities, set priorities for upgrading and capacity building, if needed.

Key issues are:

- Which are the most important collections in the world and their composition?
- What combination of collections provides an optimum coverage of the gene pool?
- Which of these collections meet the eligibility principles/criteria of the Trust? If not, are the holders willing to take the necessary steps to do so?
- What other institutions might provide conservation services (regeneration, characterisation, evaluation, documentation, distribution etc)?
- How can the global conservation be made most efficient and effective? – i.e. most cost-effective for long-term maintenance and availability?
- What collaboration and partnership agreements will need to be put in place?
- How can the global oat strategy promote strong links to farmers, breeders and other users? What steps are needed to establish and sustain such links to users?
- What are the upgrading and capacity building priority needs?

Despite initiation and funding by the Trust the Global Crop Strategies should not be seen primarily as an instrument for the Trust to guide its funding. Rather they should initiate crop networks for global strategy building, cooperation and looking also for other sources of funding.

b) General outline of consultations and people involved - a two part consultation process (Americas first and then Europe and CWANA region)

I. Experts in oat science and breeding should be consulted to develop an indicator system and score the value of oat genetic resources collections. Scientific experts have been identified mainly by consultation of scientific literature (see references) and through the participant list of the International Oat Conference in Helsinki 2004. Large scientific activity on oats is still ongoing in North America (USA, Canada), as reflected by the regular conferences focusing on oats in North America with participants mainly from the US and Canada (American Oat Workers Conference). Canadian and American oat curators strongly recommended taking advantage of the American Oat Workers Conference, held in Fargo 22-25, July 2006, bringing together experts from Canada, USA and Brazil. Thus a first consultation meeting was held from July 26-27, 2006 in Fargo, ND, USA, together with the American Oat Workers Conference focusing on the situation of the American continent. It was sought to get as much participation as possible from South America to this meeting.

II. Additional important collections are maintained in North Africa, Asia and Eastern Europe. A second meeting was held closer to these regions, in St. Petersburg, Russia, from March 1st –3rd, 2007. A complete list of experts accessed and invited for the consultation meetings is given in Appendix III.

The expertise of breeding and crop scientists, prevailing in the first meeting, should be primarily used to discuss indicators on the value of genetic resources collections and for the estimation of costs of managing certain parts of oat collections (e.g. regarding the different species). A suggestion was presented at the Fargo meeting (see Appendix V). It was emphasised, that the necessary information would not be readily available. Some participants also criticised the suggested approach as too formalistic and complicated to estimate. Thus the final meeting focused on a discussion of more general criteria to categorise collections into globally or nationally important, primarily unique or duplicated.

c) Steps taken for the development of this document

Describe the process of developing the proposed strategic approach – including people/institutions consulted etc. (full list of names and addresses in Appendix IV).

1. Identification of facilitators
2. Identification of crop experts, collections, curators and users (breeders)
3. Literature review on origin and evolution, gene pools, taxonomy and distribution, centres of diversity, use in breeding and research
4. Questionnaire to update information on oat collections
5. Stakeholders and Strategy Advisory Group Workshop (Fargo, July 2006)
6. Identification of major collections and their importance by analysis of information from available databases, the regional conservation strategies and the survey
7. Scoring management procedures of collections by comparing results from the questionnaire with accepted management standards
9. Final meeting of genebank curators and stakeholders (St. Petersburg, March 2007). Revision of draft - Global consultation
10. Finalization of strategy - Final report and suggestions for the allocation of funds by the Trust

d) The ongoing process of developing a global conservation strategy for oats – recommendations and further steps

Development and implementation of a global conservation strategy for *Avena* will be an ongoing process with distinct working phases of about 5-10 years. Each working phase will be initiated by the revision of a global oat conservation strategy plan, which formulates actions and milestones to be taken, identifies priorities for upgrading and capacity building and for long-term operation support and controls effects by previous funding. Further it identifies research and development needs and initiates projects to be funded to improve the information basis for further revisions of the strategy plan. We understand this strategy paper as an initiation of this process.

A Global Oat Diversity Network was established in St. Petersburg. A network coordination group will be chaired by A.Diederichsen, PGRC, Canada. A steering committee of the network nominated in St.Petersburg consists of I.Loskutov, N.Saidi, Z.Bulinska, Z.Zhang, M.Mackay and C.Germeier. Nordic Genebank and USDA should be invited. Louise Bondo (NGB) already confirmed that Nordic Gene Bank will participate as a member in the Steering Committee. N.Saidi will focus on helping to strengthen the involvement of the Maghreb countries, especially Algeria and its forages program. Involvement of the Middle East and of Central Asia will be necessary as well. The International Oat Conferences will be suitable as a platform for the meetings. A.Diederichsen will figure out whether it is possible to get additional persons from developing countries funded for participation in the meeting at Minneapolis in 2008. Participation from Latin America, North Africa (Algeria, Morocco, and Tunisia) and Central Asia should be assured.
Two task forces have been established to enforce the global cooperation in the fields of documentation/information and pre-breeding:

1. A task-force on a global oat information system involving the major collections was established. It will be chaired by C.Germeier with the participation of A.Diederichsen, Z.Zhang, N.Saidi, N.Tinker, M.Mackay, J.Koenig and I.Loskutov. Also Mongolia has claimed interest to participate. The task force should specifically look at the feasibility of a global index, minimum descriptors, analysis of gaps and duplicates. A revision of the IBPGR descriptor list from 1985 should be considered as well. A project proposal should be prepared by the time of the next meeting in Minneapolis in 2008.
2. A task force on pre-breeding will be led by Michael Mackay. It will propose a process for the development of a global project involving genebanks, universities, breeders and potential donors. Mike McMullen has expressed his interest to join this task force. He has experience with the use of material from the USDA collection in germplasm enhancement programs targeting to the improvement of disease resistance, and more recently, to the increase of soluble fiber concentration.

The following objectives as outlined in the proposal have been met:

- Consensus on the need for a global conservation strategy for oats. Most relevant scientific experts and curators contributed to the global conservation strategy through their participation in meetings and in the questionnaire to genebanks.
- Description of basic technical framework conditions required to deploy the strategy. A task force will work on improving global access to information on oat genetic resources. Based on a global index analysis of gaps and FIGS will form a basic technical framework for scoring the value of collections. In a first step M.Mackay will outline the technical requirements for FIGS. A task force was established to initiate collaborative pre-breeding with genetic resources to enhance their use.
- Appointment of institutions leading the process. PGRC Canada will co-ordinate the Global Oat Diversity Network. This is a natural follow-up of its leading role as a Global Base Collection. BAZ will chair the information task force, the Australian Winter Cereals Collection (AWCC) a pre-breeding initiative.
- Consensus on grant recipients. Data have been made available on collections and backlogs they face. Regeneration backlogs due to lack of personnel appear as the primary problem.

Upcoming meetings of importance: International Oat Conference, Minneapolis, USA, June 2008, ECPGR Cereal Network meeting, 2008, EUCARPIA Genetic Resources Meeting, Slovakia, May 2007. Reference should be given to the Oat Newsletter (http://wheat.pw.usda.gov/ggpages/oatnewsletter/) as a communication platform for the oat community.

II. Scientific Background

a) Oats in world agriculture

Oats (*Avena* sativa L.) are grown in many parts of the world, mainly in Northwest and Eastern Europe, North America, Canada, Australia and China. It is a crop typical of and well adapted to the cooler climates (Nordic countries, Canada). Nevertheless high quality oat is also well produced in Australia and New Zealand. Oat is not a bread cereal, but has been a staple food for a long time in Northern Europe. From a nutritionist's point of view it is our most valuable cereal crop. Contents of protein, fat, ß-glucan, minerals, antioxidants, hormone analogs in oat groats are unique in composition and quality amongst the cereal grains (Welch *et al*. 2000, Peterson 2001). Health promoting effects of oat products for human consumption have been approved by the American Food and Drug Association (1996). It is considered to be a valuable component in agriculture as oat reduces disease pressure in cereal crop rotations and is therefore highly suited for sustainable, extensive production systems. D.Stuthman and other participants at the Fargo meeting suggested that the primary focus for the allocation of Trust funds should be given to minor crops, which do no receive much support from the big players in the seed market - and especially to those which are friendly to the environment, to the landscape and to human health. D.Stuthman pointed out, that oat is the most environmentally friendly crop in the US. It is a non- host for major cereal diseases and pests. For a long time oat has been considered a "poor man's crop". Oat is covered by Annex I of the International Treaty, but is not a crop that is covered within the mandate of one of the CGIAR centres.

b) <u>Origin and taxonomy – wild and cultivated species</u>

Avena is a polyploid series from diploid through tetraploid to hexaploid. As Loskutov (2001) points out, there are cultivated forms at each ploidy level: the common oat (*A. sativa* L., 2n=6x=42); the red oat (*A. byzantina* C. Koch, 2n=6x=42); the Ethiopian oat (*A.abyssinica* Hochst., 2n=4x=28); and the grey oat *A. strigosa* Schreb. (2n=2x=14). Various genomes represented in almost 30 wild or marginally cultivated related species with different ploidy levels have to be considered (Table 1). They comprise noxious weeds in agricultural fields as *A. fatua* L. and *A. sterilis* L. including the well known *A. ludoviciana* L., and truly wild plants as native components of their local flora as *A. hirtula* (Lag.) Malzev, *A. wiestii* (Steud.), *A. canariensis* Baum, Rajhathy and Sampson, *A. murphyi* Ladizinsky (Thomas and Jones 1976). Jellen and Leggett (2006) mention 16 diploid, 8 tetraploid and 8 hexaploid species. All are autogamous annuals with the exception of *A.macrostachya*, which is a perennial, allogamous autotetraploid (Jellen and Leggett, 2006).

Table 1 Representation of the genomes (ABCD) known in the genus *Avena* within species of different ploidy levels

Ploidy	Genome	Species	Section
2n=**14**	A_sA_s	*A.brevis* Roth., *A.hispanica* Ard., *A.nuda* L., ***A.strigosa*** Schreb.	Agraria: all species have a cultivated base. 25-65° latitude North, Atlantic Europe and Canary Islands
	A_sA_s	*A.atlantica* Baum et Fedak, *A.hirtula* Lag., *A.lusitanica* (Tab. Mor.) Baum, *A.wiestii* Steudel	Tenuicarpa, 25-45° latitude North from Atlantic islands, Portugal to the Himalayan
	A_sA_s?	*A.matritensis* Baum,	
	A_cA_c	***A.canariensis*** Baum, Rajhathi et Sampson,	
	A_dA_d	***A.damascena*** Rajhathi et Baum,	
	A_lA_l	***A.longiglumis*** Dur.,	
	A_pA_p	***A.prostrata*** Ladiz.,	
2n=**28**	AABB	*A.agadiriana* Baum et Fedak, *A.barbata* Pott. ex Link.	
	AABB	*A.abyssinica* Hochst., *A.vaviloviana* (Malz.) Mordv.	Ethiopica: confined to highlands of Ethiopia and adjacent Yemen and Aden.
2n=**14**	C_pC_p	*A.clauda* Dur., *A.eriantha* Dur.= ***A.pilosa*** M.B., *A.bruhnsiana ?*	Ventricosa: 25-45° latitude North from west Mediterranean to the Himalayan
	C_vC_v	***A.ventricosa*** Bal. ex Coss,	
2n=**28**	?	**A.macrostachya**	Avenotrichon: taxonomically and topographically isolated (NW-Mediterranean Africa (Djurdjura, Aures)
	AACC	*A.murphyi* Ladiz., *A.magna* Murphy et Terell (=*A.maroccana* Gdgr.),	Pachycarpa: restricted to a small area in the southern tip of Spain and in Morocco
	(CCDD?)	*A.insularis* Ladiz.	
2n=**42**	AACCDD	*A.atherantha* Presl., *A.byzantina* C.Koch, *A.fatua* L., *A.hybrida* Peterm., *A.occidentalis* Dur., *A.sativa* L., *A.sterilis* L., *A.trichophylla* C.Koch	*Avena*

After Baum 1977, Leggett 1992, Loskutov 2005, Jellen and Leggett 2006

Several aspects of taxonomy of the genus are still under dispute. The Russian system is based mainly on Malzew (1930) and was further developed by Rodionova *et al*. (1994) and Loskutov (2003) and is extensively used in genebanks within the former COMECON region. In Canada, Baum laid the basis for the treatment of *Avena* in the PGRC world collection. Baum's monograph (1977) is still a valuable source especially of eco-geographic information (see Tables 1 and 2). He described seven sections: *Agraria*, *Tenuicarpa*, *Ethiopica*, *Ventricosa*, *Avenotrichon* and *Pachycarpa* mainly based on ecogeographic considerations (see Table 1). Loskutov (2005), more guided by morphological traits and based on Malzev (1930), divides the genus in two subgenera: *Avenastrum* (*A.macrostachya*) and *Avena*. The latter is subdivided in sections *Aristulatae* (*A.clauda*, *A.pilosa*, *A.longiglumis*, *A.prostrata*, *A.damascena*, *A.wiestii*, *A.hirtula*, *A.atlantica*, *A.strigosa*, *A.barbata*, *A.vaviloviana*, *A.abyssinica*) and *Denticulatae* (*A.bruhnsiana*, *A.ventricosa*, *A.canariensis*, *A.agadiriana*, *A.magna*, *A.murphyi*, *A.insularis*, *A.fatua*, *A.occidentalis*, *A.sterilis*, *A.ludoviciana, A.byzantina*, *A.sativa*).

The above mentioned taxonomic systems are based on a classical morphological approach. A western European school (Leggett 1992, Jellen and Leggett, 2006) has been strongly influenced by the Israeli school of Gideon Ladizinsky (Ladizinsky 1971), which stresses the biological species concept, interfertility and cytogenetic relationships. The use of different taxonomic systems makes comparison of collections by collection structure difficult for some taxa.

Loskutov (2005) gives an overview on evolution and distribution of *Avena* species. A group of species with the A, AB (AA') genome has some cultivated analogues (e.g. *A.wiestii*, *A.hirtula* -> *A.strigosa* and *A.strigosa* subsp. *nudibrevis*, *A.vaviloviana* -> *A.abyssinica*) as well as widely distributed (*A.wiestii*, *A.hirtula*, *A.barbata*) and ruderal or weedy species (*A.clauda*, *A.pilosa*, *A.damascena*, *A.longiglumis*, *A.barbata*). This group is considered to have reached its evolutionary climax and has not been part in the development of the hexaploid oats (Loskutov, 2001). Loskutov (2005) classifies these species into a subsection *Aristulatae*. The evolution of the genus involved two strikingly different genomes, known as A and C and some other genomes as their more or less distant derivatives (as A'=B, A''=D). Different variants of the A genomes have been described in diploid species (A_s: *A.strigosa*, *A.hirtula*, *A.wiestii*, *A.atlantica*, A_c: *A.canariensis* Baum, A_d: *A.damascena* Rajh. & Baum, A_p: *A.prostrata*, A_l: *A.longiglumis* (Loskutov 2001). *A.strigosa*, *A.hirtula*, *A.wiestii* and *A.atlantica* have similar karyotype and are interfertile. *A.lusitanica*, *A.hispanica* and *A.matritensis* have been demonstrated to be homologous to *A.strigosa* by DNA *in situ* hybridisation (Jellen and Leggett, 2006). Together with *A.nuda* and *A.brevis* all these species form a single biological species complex (Jellen and Leggett, 2006). Loskutov (2001) considers *A.prostrata* relatively compatible with all other species and *A.longiglumis* crossable with *A.strigosa*, while *A.canariensis* and *A.damascena* are incompatible. Jellen and Leggett (2006) found *A.longiglumis* and *A.prostrata* more related to each other than to *A.strigosa*, from which they differ by at least five chromosome rearrangements. *A.damascena* und *A.canariensis* are separate from *A.strigosa* with at least three translocations, a larger one in *A.canariensis*. They assume a common ancestor for *A.damascena*, *A.canariensis* and *A.prostrata*. A distinct and phylogenetically separate (Rodionov *et al*. 2005) C genome is represented, with incompatible variants C_p (*A.pilosa* = *A.eriantha*, *A.clauda*) and C_v (*A.bruhnsiana*, *A.ventricosa*). *A.ventricosa* is isolated from the A genome species in Algeria and Cyprus. Together with *A.bruhnsiana* it is considered the most primitive species of the section (*Eu*)*Avena* (Loskutov 2001).

Allard *et al*. (1993) considered the diploid species *A.hirtula* Lag. and *A.wiestii* Steud. as the Mediterranean and desert ecotypes respectively of a single biological species, which form a complex together with the tetraploid *A.barbata*, which originated by polyploidization from the two diploids. The genome of *A.barbata*, as well as *A.vaviloviana* and *A.abyssinica* is considered auto-tetraploid AA' (Loskutov 2001). They constitute an interfertile group with nevertheless some structural differentiation (Jellen and Leggett 2006). *A.barbata* has been widely distributed over the world, in the Americas as a prized range grazing and wild hay species (Allard *et al*. 1993).

A.maroccana, *A.murphyi* and *A.insularis* form the *Pachycarpa* tetraploid group. They differ from each other by at least four chromosomal rearrangements (Jellen and Leggett 2006). Representation of the different genomes in the world collection will have to be considered.

Allard *et al*. (1993) highlighted the ecogeographic distribution of multiallelic configurations in patchwork patterns determined primarily by available moisture and temperature. Though Spanish and Californian gene pools are closely similar in allelic composition and allelic frequencies, large differences are in multilocus genetic structure. Isoenzyme-analysis with 15 loci revealed 33 alleles and 38 genotypes common in Spanish and Californian populations, 20 alleles and 45 genotypes were found only in Spain, 2 alleles and 3 genotypes only in California (Garcia *et al*. 1989). These authors describe an increasing variability and less fixed genotypes when comparing populations in California vs. Spain or Spain vs. Israel and South-Western Asia, the former gene pools being more similar to each other than to the Eastern Mediterranean, which suggests founder effects, genetic drift and selection during the westward distribution. *A.barbata* was introduced to California by ship from Southern Spain (Garcia *et al*. 1989).

A.strigosa, *A.longiglumis* and *A.canariensis* have been suggested as source of the A genome of tetraploid and hexaploid species. Morphologic evidence points to *A.canariensis* (Loskutov 2001), cytological evidence to *A.longiglumis* (Jellen and Leggett, 2006). *A.ventricosa* is suggested as donor of the C genome (Loskutov 2001). Species with C and AC genomes (*A.ventricosa*, *A.bruhnsiana*, *A.canariensis*, respectively *A.agadiriana*, *A.magna*, *A.murphyi*, *A.insularis*) are considered transitional ancestral forms in the evolution of hexaploid oats (Loskutov 2005). Some of these species are strictly endemic or have a very limited area of distribution as wild representatives of natural undisturbed habitats. There are no other (direct) cultivated analogues of these species (Loskutov 2005). Together with the cultivated forms these species are classified into a section *Denticulatae* (Loskutov 2005). The great morphologic similarity between *A.magna* and wild hexaploids, meiotic evidence and reciprocal crosses point to *A.magna* as progenitor of the AC genome in cultivated oats, with *A.canariensis* and *A.ventricosa* as its diploid ancestors (Loskutov 2001). An earlier hypothesis considered *A.ventricosa* as donor of the C-genome and *A.magna* as donor of A and D (Rajhaty and Sadasivaiah 1969). Jellen and Leggett (2006) find no clear evidence in cytological data, how the diploids have been involved in the evolution in hexaploid oats. Regarding the tetraploids they rule out an involvement of the *A.barbata* group.

A.agadiriana, a tetraploid endemic to Morocco, is considered related to *A.barbata* based on cytological evidence and seems to currently undergo evolutionary differentiation (Jellen and Leggett 2006). It is morphologically similar to *A.magna*, *A.murphyi* and the hexaploids and according to Loskutov (2001) it is easily crossable with the latter and probably involved in their evolution. *A. insularis*, a tetraploid species found most recently, was suggested as the most likely donor of the CD genome (Ladizinsky 1999). In recent reviews it is attributed an AACC genome, but there is still debate on this group (Jellen and Leggett 2006). Hybridisation experiments with a satellite repeat sequence probe suggest CCDD for the Pachycarpa section (*A.murphyi*, *A.maroccana*, *A.insularis*) and consider *A.canariensis* and *A.damascena* D genome species (Linares *et al*. 1998). Recent analysis of C-banding and intraspecies hybridisation differentiated populations of *A.insularis* collected in Sicily and Tunisia (Ladizinsky and Jellen, 2003). *A.magna* and *A. insularis* are distinguished from *A.sterilis* with certainty only by chromosome numbers (Rajhaty and Sadasivaiah 1969, A.Diederichsen, pers.comm.2006). A “tetraploid race of A.sterilis” has been collected already 1955 in Sardinia (Martinoly 1955). Rajhaty and Sadasivaiah (1969) considered it to be *A.magna*. These authors and lastly A. Diederichsen (pers.comm. 2006) suggested a thorough chromosome survey of “*sterilis* like” plants to further reveal tetraploid accessions.

A.macrostachya is considered an autotetraploid, primitive, outstanding form most related to *A.pilosa* and *A.barbata* (Loskutov 2001). Pohler and Hoppe (1991) consider it more related to the C-genome than the A-genome diploids. The situation may be complicated by the operation of a pairing control gene in A.macrostachya (Jellen and Leggett, 2006). It is believed not to be involved in the evolution of other tetraploid or hexaploid forms (Loskutov 2001). It is the only autotetraploid species within the genus *Avena* (Rodionov *et al*. 2005), while all other tetraploid species result from hybridisation of different diploid ancestors (Badaeva *et al*. 2005).

In *Avena* areas of domestication seem not to coincide with the primary areas of distribution or the centres of origin of the weed progenitors (Thomas and Jones 1976). Malzew (1930) located the origin of the hexaploid oat in the Hindu Kush region. Baum (1972) considered *A.septentrionalis* Malz. (= *A.hybrida* Peterm.) as the closest ancestor to the cultivated oat. Its distribution from Mongolia to the Ural links the European centre with the Chinese centres of diversity of cultivated oats (Thomas and Jones 1976). Indicated by isozyme and various genetic analyses, domestication of cultivated oat currently is assumed from *A.sterilis* in two different lines of domestication leading to *A.byzantina* and *A.sativa* respectively, but both assumed in the region of Turkey, Iran and Iraq (Murphy and Phillips 1993, Zhou *et al*. 1999). *A.byzantina* forms have then been distributed primarily for use as winter forms in North Africa and Spain. They carry well known rust resistances (Red Rustproof, Red Algerian landraces).

Also Loskutov (2005, 2001) considers *A.sterilis* as the progenitor of the hexaploid cultivated species, but he locates it’s formation in the western part of the Mediterranean region (Morocco, Spain), which he considers as the primary center of origin of *Avena* L. *A.byzantina* as the eldest hexaploid cultivated form and it’s successors are assumed to have moved to the East to cover large territories in the Asia Minor centre (Loskutov, 2005). The wild (*A.ludoviciana*) and cultivated species (*A.sativa*) co-evolved and were distributed into all directions (Loskutov, 2005).

c) <u>Diversity of the *Avena* gene pool, primary and secondary centres of diversity</u>

Table 1 shows the distribution of *Avena* species as outlined by Baum (1977) and Leggett (1992). The threat of extinction will have to be considered when prioritizing countries with a considerable distribution of certain species (Table 2). The diploid species generally have more specific habitat requirements and a more localized distribution (Thomas and Jones 1976, see Table 2).

Table 2	Distribution of wild *Avena* species.	
Distribution characteristics	Species	Distribution
1. Endemic and locally rare	**A.damascena**	**Syria** (one locality on a dry wadi!), Morocco
	A.macrostachya	**Algeria**
	A.atlantica, A agadiriana	**Morocco**
	A.murphyi	**Restricted area in S-Spain**
2. Endemic and locally common	**A.canariensis**	**Canary islands, Morocco**
	A.abyssinica	**Ethiopia, Saudi Arabia,** rarely cultivated
	A.vaviloviana	**Ethiopia**
	A.maroccana	**Morocco**
3. Restricted, locally common	**A.hirtula**	**Algeria, Morocco, Spain**
4. Scattered and locally rare	**A.ventricosa**	Algeria, Cyprus, Iraq, Libya, Saudi Arabia, Azerbaidzhan
	A.atherantha	Algeria, Canary islands, Corsica, Cyprus, Egypt, France, Greece, Italy, Kenya, Portugal, Sicily, Spain, Switzerland, Tunisia, UK, Crimea Yugoslavia
	A.trichophylla	Afghanistan, Algeria, Canary islands, Crete, France, Germany, Greece, India, Iran, Iraq, Israel, Italy, Malta, Pakistan, Portugal, Sicily, Spain, Switzerland, Turkey, UK, Azerbaidzhan, Crimea, Kirghiz, Kazakh, Turkmen, Ukraine, Yugoslavia
5. Scattered and locally common	**A.eriantha**	Algeria, Bulgaria, Greece, Iran, Iraq, Israel, Lebanon, Morocco, Syria, Turkey, Azerbaidzhan, Turkmenistan
	A.longiglumis	Algeria, Egypt, Israel, Jordan, Libya, Morocco, Portugal, Sardinia, Spain
	A.wiestii	Afghanistan, Algeria, Bulgaria, Egypt, Greece, Iran, Iraq, Israel, Italy, Libya, Saudi Arabia, Sicily, Spain, Turkey, Azerbaidzhan, Ukraine Turkmen
	A.occidentalis	Azores, Canary islands, Egypt, Ethiopia, Madeira, Portugal, Saudi Arabia
6. Relatively common	**A.lusitanica**	Algeria, Canary islands, Corsica, Crete, France, Greece, Israel, Italy, Libya, Madeira, Morocco, Netherlands, Portugal, Sardinia, Sicily, Spain, Switzerland, Turkey, Yugoslavia
7. Cultivated	**A.strigosa**	Once cultivated as grain in W-Europe, adapted to poor upland soils
	A.brevis	Austria, Azores, Belgium, Canary islands, Czechoslovakia, France, Germany, Hungary, Italy, Luxembourg, Madeira, Netherlands, Poland, Portugal, Spain, Sweden, UK, former USSR, Yugoslavia Probably cultivated to larger extent in the past
	A.nuda	Austria, Belgium, Czechoslovakia, Denmark, Germany, Greece, UK
	A.strigosa	Cultivated chiefly in Wales, also in Germany, Eastern Europe: Austria, Belgium, Corsica, Czechoslovakia, Denmark, Finland, France, Germany, Hungary, Lithuania, Luxembourg, Norway, Portugal, Spain, Sweden, Switzerland, UK, former USSR
8. Weedy	**A.clauda**	Algeria, Bulgaria, Crete, Greece, Iran, Iraq, Israel, Italy, Lebanon, Morocco, Syria, Turkey, Azerbaidzhan, Georgia, Tadzhikistan, Turkmen, Uzbek
	A.barbata	Worldwide, most frequently occurring species after *A.sterilis*, a weed of poor shallow soils
	A.hybrida	Primarily in high elevations of central Asia (Nepal, Tibet, Tadzhikistan, NE-Mongolia, cold adapted), Afghanistan, Austria, Belgium, China (West), Denmark, France, Germany, India, Iraq, Japan, Luxembourg, Nepal, Pakistan, Sweden, Tibet, Turkey, UK, former USSR
	A.sterilis	Worldwide, most noxious weed in the warm temperate belt
	A.fatua	

After Baum 1977, Leggett 1992

In a presentation at the St. Petersburg meeting P.Garcia and M.Ruiz indicated the whole Mediterranean region and the Middle East including the Southern parts around the Caspian Sea as the native range of wild oats. The greatest number of biological species occurs in North Africa, Southern Spain and Sicily. FAO (1996) indicated the South and East Mediterranean sub-region, the East Asian sub-region (naked oat) and the Europe region as regions of diversity for *Avena* spp. I.Loskutov also outlined the distribution of diploid and tetraploid wild *Avena* species in three centres of diversity, the Western part of the Mediterranean (Spain, Morocco, Algeria), the Middle East and the Caspian Sea region. He assumes an evolutionary pathway starting in the Western Mediterranean and bearing different cultivated forms in different regions: *A.strigosa* in Spain, *A.strigosa* subsp. *nudibrevis* on the British islands, *A.byzantina* in Spain, Morocco and Algeria, moving to Turkey, *A.abyssinica* in Ethiopia. From *A.byzantina A.sativa* evolved on the way to Europe, *A.sativa* subsp. *nudisativa* evolved in China from naked forms of *A.byzantina* (subsp. *denudata*). For the cultivated forms Loskutov (2005) identified 7 centres of diversity: 1.) Spain and Portugal (*A.strigosa*), 2.) Great Britain (*A.nuda* L. = *A.strigosa* subsp. *nudibrevis*), 3.) Ethiopia (*A.abyssinica*), 4.) Algeria and Morocco (*A.byzantina*), 5.) Iran, Georgia and 6.) Tatarstan (hulled forms of *A.sativa*), 7.) Mongolia and China (hull-less forms of *A.sativa*).
The naked types were confined to Northern China and Mongolia, where they have been grown and used as food for 2100 years (Wang 2004). Collection of local landraces in China started in the 1950s. An independent development of hull-less oats in China is questioned by Fu *et al*. (2005), because of their close molecular similarity to the hulled forms. The hull-less condition has earlier been found in a study on the progeny of a cross between a hulled and a hull-less variety to be controlled by a single, incompletely dominant gene (N1) interacting with modifying genes (Boland and Lawes, 1973). N1 has been localized in QTL studies with another cross as well (Koeyer *et al*. 2004). It has been hypothesized, that the N1 locus encodes a regulatory molecule affecting not the hull-less character but also many other traits (Oughan *et al*. 1996, Koeyer *et al*. 2004).
J.P. Murphy and coworkers characterised the diversity of the USDA *A.sterilis* collection and North American cultivars by isozyme analysis. They revealed a considerable higher diversity of *A.sterilis* (Murphy and Phillips 1993).One half of all *A.sterilis* bands occurred at a frequency less than 0.26. By principal component analysis they revealed a close relationship of spring- and fall-sown cultivars. Grouping origin countries by relationship of *A.sterilis* accessions revealed 3-4 clusters containing (1) Iran – Iraq – Turkey - Ethiopia; (2) Algeria; (3a) Lebanon – Syria; (3b) Morocco – Israel – Tunisia – Iberia (Phillips *et al*. 1993, Murphy & Phillips 1993). The cultivated material is closer to (1) and (2). Phillips *et al*. (1993) found highest variability of *A.sterilis* in Turkey and Lebanon, decreasing in the sequence Tunisia, Iraq, Syria, Morocco - Iran –Iberia, Israel. The probability to find unique genotypes they found highest in Iran (0.013), Turkey and Lebanon (0.011). The most complete representation of genotypes was in Turkey, Morocco, Israel, Tunisia and Algeria. High polymorphic indices they found in parts of the collection from Kenya, Lebanon and Turkey. Murphy and Phillips (1993) consider Turkey as a centre of diversity for *A.sterilis* and the Turkish gene pool most interesting in regard to collecting for use in breeding. Most interesting phenotypes they allocated in Algeria, Iberia, Iran, Iraq, Israel, Lebanon, Morocco, Syria, Tunisia and Turkey.
An attempt to characterize the world gene pool of cultivated oats by molecular methods (Fu *et al*. 2005) revealed that most of the variation is within countries, while variation between countries and even regions is low. Mediterranean accessions and red types (*A. byzantina*) are most deviating while the hull-less forms extensively intermingled with common oats. Cytological studies revealed, that the red oat *A.byzantina* is separated from the common oat *A.sativa* by a major translocation involving chromosomes 7C and 17 (Jellen and Beard 2000). Additional chromosome rearrangements are observed also in the cultivated gene pool (e.g. Kanota, Siberian, Danish).
Fu *et al*. (2005) recommend that accessions from the Mediterranean and Africa and South America regions should be more weighted than those from other regions. Highest within country variation was found in Ecuador, Liberia, Kenya and Peru. Greatest deviation within the gene pool of red oat is exhibited by accessions from Egypt and Ethiopia, and by accessions from Ecuador and Chile for the gene pool of common oat. Parallel analysis based on morphological observations was presented by A.Diederichsen in the St.Petersburg meeting. The highest number of morphological groups was found in countries of the temperate zone with active oat breeding and high numbers of accessions in the collection (USA, Canada, Russia and Australia). High morphological diversity could also be demonstrated for Turkey.

d) Gene pools for oat breeding

Wild species of *Avena* are grouped into three gene pools depending on their interfertility with cultivated hexaploid oat. Whereas the primary and tertiary gene pools are extensive and diverse, the secondary gene pool is small and poorly represented in *ex situ* collections (Jellen and Leggett 2006). All hexaploid *Avena* species belong to the primary gene pool with minor restrictions on gene flow. The tetraploids *A.murphyi*, *A.maroccana* and *A.insularis* (Pachycarpa section) constitute the secondary gene pool. Hybrids of *A.sativa* with these species are partially female fertile, increasing with backcrossing. Natural recombination occurs, best with *A.insularis* (Jellen and Leggett 2006). The secondary gene pool contains several desirable traits and needs to be better explored in respect to collection as well as evaluation (Jellen and Leggett 2006).
Introgression not only from wild into cultivated, but also from cultivated into wild germplasm for the purpose of domestication has been considered. Ladizinsky (1995) introgressed domestication traits from *A.sativa* to *A.maroccana* and *A.murphyi* with the aim to use these exceptional species for the development of a tetraploid cultivated oat with large seed, high protein and better adaptation to subtropical environments. The other tetraploid and all diploid species belong to the tertiary gene pool with a very restricted gene flow to the hexaploid oat. Nevertheless it is considered a rich reservoir of diversity for oat breeding.

e) Genetic resources for resistance breeding

Wild species of all ploidy levels vary in their susceptibility for diseases. Diploid species are susceptible to *Puccinia coronata f.sp. Avenae*, but occasionally are resistant to *Puccinia graminis f.sp. Avenae* and Barley Yellow Dwarf Virus BYDV (Loskutov 2005). *A.pilosa* M.B., *A.ventricosa* Bal., *A.hirtula* Lag. are resistant to powdery mildew, *A.wiestii* Steud. is highly resistant to *Septoria* leaf rust (Loskutov 2001). The primary gene pool, especially *A.sterilis* has been extensively used in North American and Canadian breeding for rust resistance (Rines *et al*. 2006). More than 30 resistance genes have been identified and used by J.Chong in Winnipeg (A.Diederichsen, pers. comm. 2007)
Tetraploid species are generally resistant to crown rust, but not to stem rust. They have been found medium resistant to BYDV. Accessions from Spain, Italy, Greece, Turkey, Israel, Syria, Iran, Iraq, Tunisia, Algeria, Ethiopia and Morocco have been found most interesting regarding disease resistance (Loskutov 2005). *A.barbata* has been found resistant to powdery mildew, stem and crown rusts (Loskutov 2001). The perennial cross-pollinating species *A.macrostachya* Bal. is interesting for winter hardiness and complete resistance to stem and crown rusts, BYDV and aphid injury (Leggett 1992). Examples for transferring resistance factors from *A.strigosa*, *A.hirtula* and *A.barbata* into hexaploid oats are mentioned by Loskutov (2001). Breeding techniques have been made available to overcome cross incompatibility (Loskutov 2001, Thomas *et al*. 1980, Rothman 1984). Mildew resistance from *A.barbata* has been introduced into *Maris Tabard*, *Maris Oberon*, *Margam* and *Maldwyn* (Jones *et al*. 1984)
Resistances from the secondary gene pool include those against cereal cyst nematode in A.maroccana and A.murphyi, against crown rust (Pc91) in *A.maroccana* (Jellen and Leggett 2006).
From the tertiary gene pool resistances to mildew have been found in *A.barbata*, *A.hirtula* and *A.prostrata*, to rusts in *A.abyssinica*, *A.barbata* and *A.strigosa*, to BYDV in *A.barbata*, *A.macrostachya* and *A.strigosa* (Jellen and Leggett 2006). *A.macrostachya* could be also a source of winter hardiness and perenniality genes (Jellen and Leggett 2006).

f) Genetic resources for quality breeding

Several wild species have been evaluated to be valuable resources not only for resistance (Thomas and Jones 1976). Also for quality traits wild species are important resources (Miller *et al*. 1993, Welch *et al*. 2000). Most of the wild species have high groat protein and oil contents compared to cultivars (Welch and Leggett 1997). Of special interest are *A.magna* (=*A.maroccana*) and *A.murphyi*, which have been collected in Southern Spain (Ladizinsky 1971) and Morocco (Murphy *et al*. 1968, Rajhathy and Sadasivaiah 1969) and combine high protein content with high seed weight (Miller *et al*. 1993, Welch and Leggett 1997, Loskutov 2005). With 25-30% the protein content of their seed coat is considered exceptionally high (Ladizinsky 1995). They are also high in lysine and oil (Loskutov 2001). They are considered well adapted to drought and disease stresses in

North African climates (Saidi and Ladizinsky 2005). In addition they are resistant to powdery mildew and crown rust and show great productive tillering (Loskutov, 2001). Attempts of making use of these exceptional species by domestication have been already made (Ladizinsky 1995).

Diploid species have comparably great variation in percentage of husk and size of kernels with generally less desirable expression (Loskutov 2005). *A.eriantha* has extraordinarily low husk content; *A. canariensis* and *A. maroccana* have harvest indices comparable to cultivars (Welch and Leggett 1997). Wild species have been identified as resources for low (*A. clauda*, *A. longiglumis, A. pilosa*, *A. canariensis*, *A. ventricosa*, *A. eriantha*, *A. murphyi*, *A. magna*) and high (A.atlantica, A.damascena, *A. hybrida, A. hirtula*) ß-glucan content (Miller *et al*. 1993, Welch *et al*. 2000). Interesting groat protein contents (>19%) have been reported for *A.longiglumis*, *A.atlantica*, *A.magna*, *A.murphyi, A.barbata*, *A.sterilis* and *A.occidentalis* with *A.barbata* showing 5.6% lysine in protein. Interesting accessions originated mainly from Israel, Morocco and Azerbaijan (Loskutov 2005). Oil contents of 7-10% have been found in *A.pilosa*, *A.canariensis*, *A.murphyi*, *A.magna*, *A.fatua*, *A.ludoviciana* and *A.sterilis*, with high level of unsaturated fatty acids (> 46% oleic acid) in *A.hirtula*, *A.longiglumis*, *A.wiestii*, *A.barbata*, *A.vaviloiviana*, *A.magna*, *A.fatua*, *A.ludoviciana*. Interesting accessions originated mainly from Ukraine, Azerbaijan, Georgia and Morocco (Loskutov 2005).

The hexaploid wild species *A.sterilis* (Cox and Frey 1985, Schipper and Frey 1991) and *A.fatua* (Luby and Stuthman 1983) have been successfully used in breeding programs. Virtually all traits important for breeding are found in *A.sterilis*: large grains, protein up to 25%, balanced amino acid composition, oil contents up to 10%, ß-glucan up to 6%, resistance to cold, rusts, mildew, smuts, nematode injury (Loskutov, 2001). A geographic differentiation of yield components in *A.sterilis* has been described: In the Western Mediterranean few but large seeds, in the Eastern Mediterranean many small seeds dominate (Rezai and Frey 1988). This is reflected in the distribution of subspecies of *A.sterilis*: ssp. *ludoviciana* has the smallest spikelets. It is replaced by ssp. *trichophylla* with larger spikelets in the Eastern Mediterranean. In the Western Mediterranean ssp. *macrocarpa* with the largest spikelets dominates (Rajhathy and Sadasivaiah 1969).

Rezai and Frey (1988) found highest seed weight in accessions from Sardinia (TGW 16.7-19.8), Iran (6.9-27.3), Sicily (12.9-23.2), Tunisia (11.5-22.9) and Algeria (11.2-26.2) and highly significant variability in Algeria, Iran, Iraq and Israel. Highest groat protein they found in accessions from Iraq (20-30%), Libya (21-31%), Italy(20-29%), Iran (17-29%), Syria (19-30%) and Ethiopia (20-26%) and highly significant variability in Algeria, Iran, Iraq, Israel, Libya, Morocco, Syria, Turkey; high oil contents in accessions from Israel (6.5-9.9%), Ethiopia (7.3-8.9%), Algeria (6.1-10.1%), Morocco (5.9-9.2), Tunisia (6.9-8.7) and highly significant variability in Algeria, Iraq, Israel, Libya, Morocco and Turkey.

Cytoplasmatic factors increase productivity in hybrids (Loskutov, 2001). A. fatua is interesting regarding early ripeness, short culm, cold resistance, high contents of protein and oil, reduced grain shedding, resistance to rusts, smuts and tolerance to BYDV (Frey 1991).

g) Use of genetic resources in breeding

Avena are generally more recalcitrant to interspecies gene exchange than the *Triticeae*, primarily due to postzygotic sterility barriers (Jellen and Leggett 2006). Regarding use in conventional oat breeding wild *Avena* species can be grouped into four categories (Loskutov 2001):

- 1a) crosses are easily performed and result in fertile progeny: all hexaploid species
- 1b) crosses are easily performed, but progeny is partially sterile: species with C-genome (*A.longiglumis*, *A.hirtula*, *A.magna*).
- 2a) crosses are difficult and the progeny substantial sterile: *A.barbata*
- 2b) crosses are difficult and the progeny completely sterile: *A.prostrata*, *A.vaviloviana*, *A.murphyi*

Hexaploid wild species (*A.fatua*, *A.sterilis*) have been commonly used in US and Canadian breeding programs and resulted in commercial varieties e.g. *Rapida*, *Sierra*, *Mesa*, *Montezuma*, *Marvellous, Dumont, Fidler*, Multiline E77, Multiline E76, *Webster*, *Starter, Panfive*, *Centennial* and *Ozark* (Loskutov, 2001).

A.longiglumis Dur. proved to be a genetic intermediate, which facilitates crossing tetraploids with cultivated oats, which would not be possible otherwise (Thomas 1989). Especially accession CW 57 contains a gene, which suppresses homoeologous pairing restriction in *A.sativa* (Rajhathy and Thomas 1972). It was used to introgress resistance genes from *A.barbata* (Thomas *et al*. 1980) and *A.maroccana* (Rothman 1984).

III. Regional information available from regional strategies and other sources

Information on *Avena* genetic resources is available from the regional strategies, if they have considered oat as an important crop for their region. If this is not the case and oat is not mentioned in a regional strategy, this does not exclude large *Avena* collections being held in the region or the region being of significance with regard to evolution and distribution of *Avena.*

a) Americas

In the regional strategy for the Americas oat is ranked as the 16th most important Annex I crop for the entire continent. It is considered very important in Canada, USA and Mexico. Large scientific activity on oats is still ongoing in North America (USA, Canada). It has been pointed out at the Fargo meeting, that oat research and breeding in the US is mainly driven by public bodies like the North Dakota and Louisiana State Universities, the Universities of Minnesota and Florida and USDA extension centres, while private breeding restricts its focus to the big crops corn, soybean and wheat. PGRC Canada and the USDA hold the world's largest oat collections and contribute a major part of expertise to oat research. They may constitute the backbone of a global conservation strategy for oats and can play a leading role in developing the scientific basis, quality standards and organizational concepts for the global conservation of *Avena* germplasm. They are major stakeholders in the application of oat genetic resources in agriculture and breeding as well.
In Mexico the Banco Nacional de Germoplasma Vegetal in Chapingo is mentioned in the Bioversity directory with only four landrace accessions, last updated in 2002. There was no participation of Mexico in the strategy process.
The situation especially in South America was discussed in some detail at the Fargo meeting. Oat collections are listed for Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay. It was explained, that in South America, oat is mainly used as a forage crop for hay and grazing. Molecular work by Fu *et al*. (2005) suggests giving more attention to germplasm of cultivated oat from South American countries. Ecuador and Peru are explicitly mentioned. Institutions from both countries have participated in the questionnaire, unfortunately too late for being involved into the Fargo meeting. For Ecuador A. Monteros from the Instituto Nacional Autónomo de Investigaciones Agropecuarias responded to the questionnaire and confirmed 544 accessions listed as breeding lines in the Bioversity Germplasm Directory. He considers about 430 accessions, almost 80% of his collection, as being of national origin. Thus, it might be an interesting collection with regards to the results of Fu *et al*. (2005). For Peru, Bioversity (Directory) listed two collections with together 1215 accessions, last updated in 1999. L.G.Pando from the University of La Molina, the larger one of both responded to the survey (see section IV). She considers most of her material (95%) as being introduced from other collections (see section IV).
F.Condon from INIA la Estanzuela, Uruguay, confirmed at the Fargo meeting, that oats especially in the REGENSUR countries (Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay) grow under high disease pressure. As a result this region develops into a secondary diversity centre evolving interesting traits of disease resistance. L.C. Federizzi from the Federal University of Grande do Sul, Brazil, explained, that oat is grown mainly in the Southern parts of South America, namely South Brazil, Uruguay and Argentina. Originally it has been introduced to Brazil from Argentina and Uruguay and breeding efforts have started there already in 1925. A major shift in Brazilian oat germplasm came with the Quaker oat introductions in the 1970s. In the Brazilian Network of Genetic Resources (RENARGEN) oats currently play only a small part. From 1967, Brazil developed an oat production of 500,000 tons per year. Before this time, all oats had been imported from Argentina. Argentina still has the only oat mill in South America. Nevertheless activity in oat breeding and genetic resources work seems much more active in Brazil than Argentina. Only five accessions, reported in 2002, are listed for INTA Argentina in Bioversity (Directory). There was no participation of Argentina in the strategy process.
Bioversity (Directory) lists four collections for Brazil. The situation in Brazil was explained in some detail by L.C. Federizzi at the Fargo meeting. The Genetic Resources and Biotechnology Center leads a national Network of Genetic Resources (RENARGEN, http://www.cenargen.embrapa.br/), consisting of 235 germplasm banks with 250,000 entries of plants, animals and microorganisms. Oat is represented in network component two, dedicated to conservation, characterisation and use of cereal genetic resources by the target exotic germplasm plus adventive species. He mentioned four collections: 1.) the CENARGEN/EMBRAPA collection

holding 512 accessions as listed in Bioversity (Directory) and confirmed by C.O.Goedert in the questionnaire; 2.) The collection held by IAC Campinas, listed in Bioversity (Directory) with 405 accessions, which he explained to be old material from a rust program, including three accessions of wild species; 3.) the Wheat National Centre, which is listed in Bioversity (Directory) with only 46 modern cultivars. This information was updated by E.J. Iorczeski in the questionnaire reporting 349 accessions including 74 accessions of diploid species (*A.strigosa* 58, *A.brevis* 10, *A.longiglumis* 5, *A.wiestii* 1), 125 of tetraploid species (*A.abyssinica* 50, *A.barbata* 50, *A.vaviloviana* 22, *A.magna* 3) and 130 hexaploids (*A.sterilis* 52, *A.sativa* 77, *A.byzantina* 1). L.C.Federizzi mentioned 4.) his own working collection at University of Grande do Sul with about 900 entries. Bioversity (Directory) additionally reports an EPAGRI collection with 26 landrace accessions in Lages Santa Catarina, last updated in 1999. It is also mentioned with 50 accessions in Knudsen (2000). For APTA V.L. Nishijima Paes de Barros reported 1161 accessions to the questionnaire.
A major target in Brazilian oat breeding is earliness. Oats are regularly grown from June to December. Soybeans, the major cash crop would need to start in November. Thus a forty days earlier maturing oat cultivar would be necessary. Tolerance to abiotic stresses (high variation in temperature and frost); better fertilizer uptake, resistance to biotic stresses (rust, *Fusarium*, *Pyrenophora*, *BYDV*), early vigor and competitiveness with weeds for no-till systems and wide adaptation are further priorities in oat breeding. Aluminum tolerance is highly expressed in oats. ß-glucan, Avenanthramides, sensory and texture factors, low and high oil content are considered as important quality traits. *Avena strigosa* is cultivated in Brazil as cover crop and for hay.
F. Condon explained for Uruguay, that *A.strigosa*, *A.sativa* and *A.byzantina* are exclusively used as a fodder crop for grazing and hay production. Market for oats in human nutrition is small and served by imports from Argentina. Late developing and abundantly tillering cultivars are used. He mentioned several regional PGR networks for South America, which currently have a limited focus on *Avena*, but could play an important role in the process: NORGEN with Canada, USA and Mexico; REMERFI with Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica; CAPGERNET with Barbados, Cuba, Dominican Republic, Guadeloupe, Martinique, Guyana; TROPIGEN with Bolivia, Colombia, Venezuela, Brazil, Ecuador, Suriname; REDARFIT with Bolivia, Colombia, Ecuador, Peru, Venezuela and REGENSUR with Argentina, Bolivia, Brazil, Chile, Paraguay, Uruguay. Especially for the latter network he confirmed, that there is close cooperation between the countries.
In Chile two collections are listed by Bioversity (Directory) with together 152 accessions. No *Avena* collections have been reported in Barbados, Bolivia, Costa Rica, Cuba, Dominican Republic, El Salvador, Guadeloupe, Guyana, Guatemala, Honduras, Martinique, Nicaragua, Panama, Suriname and Venezuela, in Colombia only one accession.

b) Europe

Although acreage grown to oats is continuously declining in Europe as well, *Avena* still plays an important part in the genetic resources work within the European Cooperative Programme for Plant Genetic Resources (ECPGR). This program has been established as a platform to strengthen cooperation of European *ex situ* collections already in 1980. The *Avena* Working Group has been established in 1984 as one of the original six Crop Working Groups and since then has held seven meetings. The European *Avena* Database (EADB) established also in 1984 at the former Braunschweig Genetic Resources Collection (BGRC), is now managed by the JKI – Federal Research Institute for Cultivated Plants, with passport data of 32,910 accessions representing collections from 26 European contributors and nearly 170,000 characterisation and evaluation observation points for 3134 accessions, gathered mainly in an EU project running from project 2000 – 2004 under the regulation EC 1467/94 entitled "Evaluation and enhancement of *Avena* landrace collections for extensification of the genetic basis of *Avena* for quality and resistance breeding“ and by projects of I.Loskutov at VIR. I.Loskutov also contributed the data part to a module on alleles known in the *Avena* germplasm. The FAO/IPGRI Multi-Crop Passport Descriptors is adopted for passport data exchange. The information system is able to deal with parallel multiple taxonomic systems with the biological species concept as the primary reference to species and the Rodionova/Loskutov systems as primary reference to subspecific taxonomy. A taxonomic key system for biological species including photographs is also available. *Avena* will be also funded by the European Community within the regulation 870/2004 with a project focussing on quality traits for human consumption in European oat germplasm.
Avena is one of four model crops represented in a European initiative for An European Genebank Integration System (AEGIS), which also represents the regional strategy for Europe. It has been the outcome of discussions on options for sharing conservation responsibilities already since 1998. Main difficulties that have been

discussed are lack of long-term conservation facilities, insufficient safety-duplication and regeneration backlogs. Expected outputs are very similar to the Global Conservation Strategies: assess different approaches and propose models of cooperation, discuss pros and cons, propose an organizational structure, address legal and political issues, analyze the concept and propose 'Most Appropriate Accessions' to be submitted to the system and draft guidelines on quality standards for long-term conservation. The *Avena* subgroup prefers a decentralized system as primary model, by sharing of responsibilities at an accession basis, taking country of origin for cultivated material or country of collector for wild material into primary consideration for defining the Most Appropriate Accessions. Therefore, sub-regional considerations are the starting point for deciding on primary conservation responsibility.
Within Europe Spain is of special importance, as it is located in the centre of diversity. Distribution and status of threat for the wild *Avena* species in Spain have been outlined at the St.Petersburg meeting by P.Garcia and M.Ruiz. *A.hirtula*, *A.barbata, A.fatua* and *A.sterilis* are widespread in Spain: *A.barbata* is spread all over the country, *A.hirtula* predominately in the Western parts, *A.fatua* in the Northern parts. *A.sterilis* subsp. *ludoviciana* occurs in Northern Spain, *A.sterilis* subsp. *sterilis* in the Southern parts. Species with restricted distribution are *A.longiglumis*, *A.canariensis*, which is endangered, *A.prostrata* with unclear status and *A.murphyi*, which is vulnerable. *A.longiglumis* is restricted to a small area at the Southern coast Southeast from Huelva and the Canary islands, *A. canariensis* is known in Lanzarote and Fuerteventura, *A.prostrata* near Cartagona (San Julian, San Francisco) and *A.murphyi* at the very Southern tip near Algericas (Tahivilla, La Negra, Facinas, Bolonia). Additional species with unclear status of threat have been described in Spain: *A.brevis*, *A.hispanica*, *A.lusitanica*, *A.matritensis*, *A.wiestii*, *A.eriantha*, *A.atherantha*, *A.trichophylla* and *A.occidentalis*.
Oat currently deserves the third largest acreage behind barley and wheat in Spanish agriculture with an increasing annual production since 1996.

c) West Asia and North Africa

The Regional Strategy for the Conservation of Plant Genetic Resources in West Asia and North Africa mentions oat as a crop of primary importance and the 3rd most important cereal after barley and wheat. In a list of ten priority crops, oat is ranked in the last position. According to the size of the collection, oat with 4089 accessions in four holdings, ranks eighth amongst the food crops in the *ex situ* collection in this region. It is considered of key importance as the region is the assumed centre of origin (Mediterranean and Near East) and oat is cultivated as food (breads) and for feeding the animals. It has been ranked of highest importance (1) for North Africa (NA): Algeria, Egypt, Libya, Morocco and Tunisia; as important (2) for West Asia (WA): Iran, Iraq, Jordan, Lebanon, Pakistan, Palestine, Syria and Turkey; and as not important (4) for the Arabian Peninsula (AP): Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates and Yemen. The regional strategy lists 2133 accessions at INRA Morocco, 814 at NGB-AARI Turkey, 540 at NARC Pakistan, 500 at NGB Iran, 30 at MOA Tunisia, 20 at NGB Egypt, 20 at GCSAR Syria, 18 at ARC Libya, 9 at INRAA Algeria, 3 at AREA-NGRC Yemen, 1 at NCARTT Jordan, 1 at MAF Oman 1.
Some more information about oats in the Maghreb region and a focus on Tunisia has been kindly provided by Mohammed Chakroun and Mohamed Bechir Allagui, INRAT, Tunisia:
Oats (*Avena* spp.) are the most important fodder crops in the Maghreb (Algeria, Libya, Morocco and Tunisia). They are mainly used for hay and silage (Al Faiz *et al*., 2004). Although the Maghreb is rich in oat genetic resources, it relies heavily on introduced varieties for the viability and sustainability of its livestock production. Until the early 1990s, all the varieties used were introduced.
Several *Avena* species (diploid, tetraploid and hexaploid) exist in the Maghreb, the centre of diversity for the genus. Three diploids (*Avena atlantica* Baum et Fedak sp. Nov., *A.damascena* Rajhathy et Sampson and *A. prostrata* Ladiz) were found mainly in Morocco. Three tetraploids (*A. maroccana* Gdgr., *A. murphyi* Ladiz. and *A.. agadiriana* Baum et Fedak sp. Nov.) are endemics to Morocco, one (*A. insularis* Ladiz.) endemic to Tunisia and probably Algeria (Ladizinsky and Jellen, 2003), and one perennial and cross pollinating species (*A. macrostachya* Bal. ex Cross et Dur.) has been found only in the Algerian mountains. Four hexaploid species include the cultivated oats (*A. sativa* L. and *A. byzantina* C. Koch), which are common in all countries and cultivated in areas ranging from the semiarid temperate to the more humid climates. The weedy species (*A. sterilis* and *A. fatua*) are found in large areas and are the most widely distributed. Many small niches in different regions of Tunisia still need to be prospected for *A. longiglumis*, *A. alba*, *A. fatua*, *A. sterilis* and *A. bromoides* (Guénod, 1954). A small effort has been ongoing to prospect these species. Along with this activity, seeds need to be prepared for long-term storage. *A. insularis*, recently discovered (Ladizinsky and Jellen, 2003) is

under threat of genetic erosion in the areas of its natural distribution. These areas are suffering from land degradation caused by the conversion of grazing lands into cultivated fields. Collection and storage of this indigenous germplasm is needed. This species is known to exist in areas less accessible to stock and could still be collected. Conjugated effort with the other Maghreb countries would be needed. In Tunisia, the genetic base of cultivated oats is narrow. The local genotypes (*A. byzantina* C. Koch) still have the first place as fodder crops despite their susceptibility to crown rust (*Puccinia coronata* Cda. f.sp. *Avenae* Eriks.), the most damaging foliar disease. The goal of the oat breeding program at INRAT is to develop superior varieties with good adaptation, high forage yield potential and good tolerance to the prevailing foliar diseases, particularly crown rust, using different sources of germplasm. In fact, the oat breeding program relies heavily on international germplasm received from overseas material. Research conducted in the 1980's and 1990's has made possible the development of four varieties: Fretissa, Al alia, Mejerda and Meliane (Deghaïs *et al*., 1999) which are in production. The current oat improvement program consists of the evaluation of a number of lines received from the Quaker Oat International Nursery (QOIN). Dry matter productivity and tolerance to crown rust are the principal selection criteria. A number of lines have already been selected for further evaluation in different oat growing regions. Distinguished lines will be released as varieties.
In 2003, systematic plant exploration has resulted in the collection of nine local genotypes of *A.byzantina* C. Koch from farmers in different regions of northern Tunisia. This activity has resulted in the identification of three promising landraces. Genotypes *Maacher*, *Nefza* and *Sidikhiar* present high dry matter yield and acceptable tolerance to crown rust. These genotypes may constitute the base of crosses between *Avena sativa* and *Avena byzantina* to better increase the value and productivity of oats in the favorable production regions. In Tunisia, resistance of oat varieties to crown rust disease is regarded desirable. Ninety samples of several spontaneous oat species have been collected from different Tunisia's regions (Cap Bon, Zaghouan, Tabarka, Aïn Drahem, Beja and Bizerte). The seeds were tested for crown rust resistance *in vitro*. Ten spontaneous accessions showed a resistance to crown rust. Seeds of every accession were harvested.
Nezha Saidi from INRA Morocco represented the Maghreb region at the final meeting in St. Petersburg. 5.2 million ha are grown to oats in total North Africa. The cultivated oat has been introduced to Morocco in the late 1920s by the French. In 2006 82 000 ha have been planted with oats in the Northern parts of Morocco, making about 36% of the forage crops grown in the rain fed area. Forage yields are highly variable because of the use of varieties not well adapted to local conditions, the use of non-certified seeds, and lacking respect of cultural practice. To improve this situation, INRA Morocco in the 1980s started the selection of new varieties of common oat (*A.sativa*) for different ecological areas: favorable rainfed areas, semi-arid areas and highlands. INRA Morocco participates in the Quaker oat nurseries. It has 12 hulled varieties and one naked nationally registered, but yield, disease resistance and adaptability especially in dry seasons is not yet considered sufficient. The wild species play an important part in the breeding program. Morocco is considered a centre of diversity of *Avena* and has 11 diploid, 6 tetraploid and 8 hexaploid species growing in the wild. Seven collecting missions have been undertaken together with M.Leggett and G.Ladizinsky from 1985-2002 resulting in a rich collection of rare or endemic species. Supervised by G. Ladizinsky, domestication experiments and crosses with the two tetraploid species *A. magna* and *A. murphyi* have been initiated to improve groat protein content, adaptability and disease resistance in cultivated oats. Groat protein contents up to 19% have been achieved in this program. Efforts to collect more wild genetic resources for *ex situ* conservation, implementation of an *in situ* conservation strategy as a complementary way to safeguard especially the highly threatened taxa and financial support for urgent regeneration of all existing collected material are considered of primary importance. Needs are seen also for molecular characterisation of the material and increased valorization extending its use for human consumption.
In Algeria, Tunisia and Morocco currently financial restrictions and the resulting lack of staff are the main problems. The governments do not consider oat as a priority crop and financial support for the *Avena* collections are being reduced. Extreme genetic erosion is to be expected under the climatic change.

d) West and Central Africa

The regional strategy for West and Central Africa does not include oat in the 10 most important crops.

e) Eastern Africa

The Regional Conservation Strategy for Crop Diversity Collections in Eastern Africa does not include oat in the 21 most important crops. Thus oat / *Avena* are not mentioned. Nevertheless, one of the largest oat collections mentioned by FAO (1996) and respective databases at FAO and Bioversity, e.g. the Bioversity Germplasm Directory with more than 10.000 accessions is reported to be held by two institutions in Kenya. According to results of the questionnaire undertaken in the framework of this study (see section V) the current number of *Avena* accessions in the National Genebank of Kenya is about 4200. It is the second largest collection within this genebank. Z.K. Muthamia represented Kenya at the final meeting in St. Petersburg. The National Genebank was established in 1988 with financial support of GTZ, Germany. It exists within the framework of the Kenya Agricultural Research Institute (KARI). Of the oat accessions 208 originate from Germany, a much larger part (2097 accessions) from USA. Most of them probably had entered the country already before the establishment of the genebank. Participants in the Fargo meeting remembered a national and international stem rust initiative in Kenya. Z.K. Muthamia considers the collection in Kenya as a duplicate collection of accessions from various countries. He is not aware of any efforts to develop or even multiply this material in Kenya and raised the question, whether this material should continue to be kept in Kenya or somewhere else. Despite some demand for oat flour and low sugar lines, which can result in higher prices for oat than even for wheat, there is no major national research activity on oats due to low funding. Evaluation of the collection, especially for disease resistance would be required.
Two *Avena* species, *A.abyssinica* and *A.vaviloviana* are endemic to the Eastern Africa region, namely to Ethiopia. The collection of the International Livestock Research Institute (ILRI), which is localized in Ethiopia, responded to the survey (see section V). Even upon request it was not possible to get information, whether the endemic *Avena* species are recognized in the Ethiopian genetic resources community. G.Ladizinsky clarified in the St.Petersburg meeting, that *A.abyssinica* is very wide spread as a weed in Ethiopia. It is not threatened at all and probably no need is seen for the conservation of this species.

f) Southern Africa

The Conservation Strategy for Crop Diversity Collections in SADC Region sees no mandate for oats in the South Africa region. One accession is listed in Lesotho. Nevertheless considerable collections have been listed in the Republic of South Africa with together more than 600 accessions.

g) Central Asia and Caucasus

The regional strategy for Central Asia and Caucasus does not include oat in the 25 most important crops. Loskutov considers Iran, Georgia and Tatarstan as the centre of diversity for the hulled forms of *A.sativa*. It seems that very little work on oats is done in that area; however there are plenty of oats in the region, mostly wild oats.
Some information was provided by Dr. Bitore Djumakhanov, ICARDA Tashkent. In the genebank of the Uzbek Research Institute of Plant Industry (UzRIPI) the *Avena* collection comprises 648 accessions of cultivated varieties: *A.sativa* 47, *A. byzantina* 34, *Avena* sp. (not specified) 567. Accessions originated from 54 countries of the world. Prof. Igor Belolipov, head of botanic department of Tashkent Agrarian University reported that eight wild species of oats are available in the region: *A.eriantha* Dur, *A.barbata* Pott ex Link, *A.meridionalis* Malz, *A. fatua* L., *A. sativa* L., *A.clauda*, *A.trichophylla*, *A.ludoviciana* Dur. Seeds of wild species of oats are not studied. In the last 15-20 years there has been less interest in wild species of all crops.

h) South, Southeast and East Asia

The Regional strategy for conservation and utilization of crop diversity in the South, Southeast and East Asia region does not include oat in the 15 most important crops. Thus oats or *Avena* are not mentioned, though the East Asian sub-region is known as diversity region for the interesting naked forms of A.sativa (*A.sativa* ssp. *nudisativa* (Husn.) Rod. et Sold). Their origin is assumed to be especially in Inner Mongolia, which now belongs to China.

Only 1500 oat accessions have been mentioned for China in the World report (FAO 1996). More recent sources listed 3171 oat accessions in China (Xu, 2002) and 1336 in Mongolia (Altansukh 2002). Wang (2004) reported 1663 accessions of naked oats in the Chinese germplasm collections, 953 originating from Shanxi, 456 from Inner Mongolia. Recent information can be found in section V. China and Mongolia were represented in the final meeting in St. Petersburg by Z.Zhang and N.Bayarsukh respectively. In China naked oats are used primarily for food, hulled oats for feed. Compared to hulled oats naked oats have lower crop height, less spikelets on the main panicle, less seed yield per plant and less seed weight. Oats are recognized as healthy food by reducing blood fat and regulating blood sugar. Oat cultivated in China has a tradition for over 2000 years. Current cultivation is about 0.3-0.6 million hectares with an annual production of 0.4-0.8 million tons, mainly in Shanxi, Hebei, Inner Mongolia, Shaanxi, Gansu, Ningxia and Qinghai. Collecting activities throughout the country had started in 1950s, however, most of the early collected materials have been lost during the cultural revolution. Collecting and also exchange and introduction of oat germplasm from foreign countries was re-organized in the late 1970s resulting in 2600 accessions collected within China and 1200 accessions introduced from abroad. Descriptors used for characterisation are seedling growth habit, seedling color, panicle type, spikelet shape, kernel shape, and kernel and lemma color. Information on quality traits (protein, fat, linoleic, oleic and anomic acids) is available for about 10% on resistances against smut, BYDV, aphids and lodging resistances for about 8% of the collection. The Chinese oat collection is a national collection with a centralized base collection at the Institute of Crop Science of CAAS in Beijing, which has represented most of the accessions of several working collections located in Beijing, Inner Mongolia, Shanxi, Hebei and Ningxia. Most of the oat accessions originated in Shanxi (1215) and Neimeng (525). More details on the Chinese oat collection can be found in section V.
Outer Mongolia covers in total 1.5 million square kilometers at an average altitude of 1580 m above sea level. The climate is extreme continental with average temperatures from -30 to +30 °C, low precipitation of 200-350 mm per year and a short growing period of 90-100 days. Oats like barley and rye are mainly used as green chop silage for dairy cattle (Altansukh 1996) or as hay, silage and feed grain. In 1990s 35-45 thousand ha have been grown with oats with a total annual production of 80-100.000 tons. From nearly 30 priority crops needing urgent action in breeding and seed production oat has been listed at third position (Altansukh 1996).
Led by the Vavilov Institute, collecting trips to Mongolia were undertaken in 1921-22, 1930-1932, 1958, 1972 and 1990 (Altansukh 1996). V.E.Pisarev in 1921 described the occurrence of botanical varieties of hulled (*mutica*, *aristata*, *aurea*, *krausei*, *grisea*, *cinerea*, *brunnea*) and hull-less oat (*chinensis*, *mongolica*)
N.G. Khoroshailow and A.Khuchit in 1958 described the occurrence of varieties *grisea*, *grisea, prunosa* and *cinika*. They found new types *baidarica* and *ullyasutaika* and very early naked types *chinensis*, *mongolica* and *maculata*. The plant breeding activity in Mongolia was intensified since the end of 1950s. National collecting missions from 1958-1972 collected 46 oat landraces, which are now conserved in the national genebank. A variety Mutika-832 has been developed from local landraces with protein contents of 17-18% and growing well under rain fed conditions. It has been registered as a donor variety for protein improvement in Russian breeding programs. Naked varieties from Mongolian breeding programs are *Uburmongol* and *Nudum* –17. The Plant Science and Agricultural Research and Training Institute (PSARTI) conducts research on various aspects of crop improvement and crop cultivation technologies and has a PGR Division holding 19,000 accession of various crops including nearly 1336 oat germplasm accessions (see section V). This is the only seed conservation facility under the Government of Mongolia (Zhang, 2006, Bayarsukh, 2006, pers. comm.).

i) <u>Pacific</u>

The Regional Strategy for the *ex situ* Conservation and Use of Crop Genetic Diversity in the Pacific Islands Region does not include oat in the 11 most important crops. Thus oat or *Avena* are not mentioned.

j) <u>Australia and New Zealand</u>

The regional strategy for Australia considers oat as one of the main crops of interest for the Australian Grains Research and Development (GRDC). M.Mackay reported that while a considerable area of oats is grown in Australia, the investment in research has been declining in recent times. The current activity in the AWCC is around 74% wheat, 24% barley and 2% oats, which closely reflects the level of investment into research for the three crops.

From New Zealand Keith Armstrong reports that oats are primarily grown for forage green feed / silage, and as a grain feed. Relatively very little is now processed for human food. Research and Development, including breeding priorities reflect these production trends, with most research effort now focusing on improving green-feed / silage performance and disease, especially crown rust, stem rust and Barley Yellow Dwarf Virus. All public research effort is within The Institute for Crop & Food Research Ltd, a Crown Research Institute, which also maintains the only publicly accessible oat germplasm collection. Some overseas oat germplasm is imported and evaluated by various private seed companies for the greenfeed / silage and grain feed markets. 95% of the cultivars used in New Zealand were bred and released by Crop & Food Research

IV. Overview of major collections

a) Data sources

The following data sources could be used to get a global overview of *Avena* collections
Global information:

- FAO (1996): Report on the State of the World's Plant Genetic Resources for Food and Agriculture.
- FAO WIEWS Database (http://apps3.fao.org/wiews/germplasm.htm)
- Directory of Germplasm Collections (http://web.ipgri.cgiar.org/germplasm/default.asp) hosted by Bioversity International (Bioversity). Specially formatted exports were kindly provided 2006 and 2007 by B.Laliberte and R.Sood: 117 addresses of oat collections

Regional information:
Europe:

- ECP/GR information available for the *Avena* working group and from participation of the facilitators with *Avena* in an initiative called An European Genebank Integration System (AEGIS): 43 addresses
- Address information available from contributors to the EADB: 34 addresses and EURISCO: 32 addresses.

Canada and North America:

- Personal contacts of the facilitators from bilateral cooperation activities between Germany and Canada and USA respectively

South America:

- Knudsen (2000)

Other regions:

- Draft regional strategies provided by the Trust.
- Internet search.

Databases and online information systems:

1. European *Avena* Database (version 2006)
2. EURISCO downloads (2006/2007) for genus *Avena*
3. USDA GRIN and PGRC GRIN special exports provided by the database management units

Tables and databases provided by respondents to a questionnaire.
Only little information on number of accessions or collection structure was taken directly from institute's internet representation. This reflects the fact, that either online information on collections is still scarce or difficult and cumbersome to find or not suited to extract summary information.

b) Location of oat genetic resources in *ex situ* collections

About 220.000 accessions of oats in *ex situ* collections have been estimated in the report on the State of the World's Plant Genetic Resources (FAO 1996). The Bioversity (formerly IPGRI) Directory of Germplasm Collections lists 117 collections with 113,520 accessions in 56 countries. In total quantitative collection information could be identified for 119 collections, which are listed in full in Appendix I.
Large collections are held by the USDA (http://www.ars-grin.gov: 22,242 accessions), the PGRC (http://pgrc3.agr.gc.ca/cgi-bin/npgs/html/acc_query.pl: 26,548 accessions) and within the framework of the ECP/GR (http://eadb.bafz.de: 34,146 accessions), namely by the Vavilov Institute of Plant Industry VIR (11,684 accessions), which has a collection of about 10,000 accessions of four cultivated and 2000 accessions of 21 wild species (Loskutov 2001). For those about 90,000 accessions documentation is easily accessi-

ble in the internet. Further large collections have been mentioned by FAO (1996) in Kenya (ca 13,000 accessions), in Israel (7500 accessions), the latter announcing an especially rich collection of *A.sterilis* (5000 accessions, http://www.agri.gov.il/Depts/GeneBank/Genebank.html) and in Australia. In FAO/WIEWS 29 collections are listed maintaining accessions of wild *Avena* species of which 13 hold more than 20 respective accessions (BRA102, CAN004, CHN001, DEU146, ESP004, GBR011, GBR016, ISR003, MAR071, NOR038, POL003, RUS001, SWE002, USA029).
85 collections are listed holding *Avena* sativa, 42 with more than 200 accessions (AUS003, BEL003, BRA003, BRG001, CAN004, CAN015, CAN017, CAN091, CHN001, CHN029, CZE047, DEU146, ECU023, ESP004, FIN020, FRA010, GBR011, GBR015, GBR165, IRS002, IRS003, IND001, IND027, ITH060, JPN003, JPN055, KEN015, KEN051, NLD037, NOR038, NZL027, POL003, RUS001, SWE002, SVK003, SYR002, URY003, USA005, USA029, ZAF001, ZAF050, ZAF049).
A full list of collections found in the data sources used for this study is given in Appendix I, their addresses in Appendix IV.
As the Convention on Biological Diversity (CBD) and the International Treaty (IT) reinforce the national sovereignty on biological diversity, centres of diversity need primary consideration in developing a global conservation strategy, also with respect to complementary actions of *ex situ* and *in situ* conservation.

c) Species representation in the World *Avena* Collection

Wild *Avena* species are much more difficult to maintain and regenerate than cultivated oats. Their safeguard is a major concern in parts of the oat community. Yet their importance is also questioned. Especially the secondary and tertiary gene pools are difficult to use in breeding. G.Ladizinsky suggested that this should be reflected by a clear focus on the primary gene pool in genetic resources work. Also in PGRC Canada the hexaploid material has been rejuvenated with priority. *A.sterilis* has been very important in breeding programs for crown rust resistance. It is still widely used in South American breeding programs. On the other side it was mentioned in the Fargo meeting, that scientific study found no clear evidence that genes from *A.sterilis* gene pools are better than genes from *A.sativa* gene pools. In the US *A.sterilis* is considered a serious weed and work with this species needs special permission.
Successful breeding including more distant gene pools, even the outstanding perennial species *Avena macrostachya* has been mentioned as well. Domestication experiments with *A.magna* and *A.murphyi*, supervised by G. Ladizinsky, have been made in Morocco. R.Jonsson mentioned successful breeding programs (backcrossing after selection for seed size and disease resistance) with the secondary gene pool (*A.murphyi* and *A.magna*), in which Svalöf Weibull had participated in the 1970s and 1980s. They resulted in breeding lines with good overall performance and probably no yield penalty. Budgets for oat breeding were less restricted in these times and he considers similar activities impossible under the current economic restrictions for oat breeding.
It has to be taken into consideration that marginally cultivated species exist at all ploidy levels. At least the diploid *A.strigosa* has been of considerable importance in Northern Europe in the past and is still widely used for hay in South America. In the Fargo meeting, experiences from Uruguay and Paraguay have been mentioned to use *A.strigosa* as a nematode suppressing crop. In Brazil breeding programs are ongoing with *A.strigosa*.
Table 3 shows the representation of different species in *ex situ* collections according to the available data sources. Species with a low representation in the world collection are printed in bold. In some cases, a low representation may also be caused by the fact that the botanical systematic of the genus *Avena* is not yet fully settled and different taxonomic systems are used in different collections. For example only two accessions in the French collection are determined *A.macrocarpa*. Rajhathy and Sadasivaiah (1969) indicated *A.sterilis* of Western Mediterranean origin and large spikelets as *A.sterilis ssp. macrocarpa* (see section II). *A.hispanica* is mentioned only from the Canadian collection. Together with other marginally cultivated species, *A.nuda* and *A.brevis*, it belongs to a biological species complex with *A.strigosa* (Jellen and Leggett, 2006). Also *A.lusitanica*, which is put into the same species complex by Jellen and Leggett (2006), is mentioned only by PGRC. Only few accessions in the VIR collection are determined *A.bruhnsiana*. *A.bruhnsiana* is considered a synonym of *A.ventricosa* (IOPI, 2006). If a species name is not valid in the light of the biological species concept, this does not rule out its usefulness in the characterisation of diversity at a subspecific level.
Nevertheless poor representation is obvious for *A.atlantica*, *A.damascena*, *A.nuda*, *A.prostrata*, *A.ventricosa*, *A.macrostachya*, *A.agadiriana*, *A.insularis* and *A.murphyi*. *A.insularis* has been very recently detected with four

populations near Lake Columelli between Gela and Butera in Southern Sicily (Ladizinsky 1998) and in Tunisia (Ladizinsky & Jellen, 2003). It has been found exclusively on uncultivated land, which had either never been cultivated or had long been abandoned and is thus very rare in its region, which is almost totally under cultivation. As it is morphologically very similar to *A.sterilis*, it is assumed, that more tetraploid specimens might be present in the existing large *A.sterilis* collections and it is recommended to screen these collections for chromosome number, e.g. by flow cytometric methods (A.Diederichsen, pers. Comm. 2006).

Table 3 Representation of *Avena* species (number of accessions) in *ex situ* collections according to different data sources

GENOME		SPECIES	Surveys	EADB	EURISCO	Directory
A) The common oat (cultivated hexaploid oat)						
42	ACD	*A. sativa*	56609	28502	25203	70887
42	ACD	*A. byzantina*	430	2052	1828	1324
B) Wild relatives in the primary gene pool (hexaploid species)						
42	ACD	*A. diffusa*	8	8	8	8
42	ACD	*A. fatua*	2342	762	464	1686
42	ACD	***A. hybrida***	**25**	**9**	**2**	**1**
42	ACD	*A. ludoviciana*	444	435	437	425
42	ACD	*A. macrocarpa*	2			
42	ACD	*A. occidentalis*	71	7	7	7
42	ACD	*A. sterilis*	23080	1939	1247	15072
C) Marginally cultivated species (diploid and tetraploid)						
14	A	*A. strigosa*	697	458	420	524
14	A	***A. nuda***	**39**	(228)	**32**	(1705)
14	A	*A. brevis*	87	35	33	49
14	A	*A. hispanica*	16			
28	AB	*A. abyssinica*	615	164	138	418
D) Wild relatives in the secondary gene pool (tetraploid species)						
28	AA	***A. macrostachya***	**13**	**3**	**1**	**12**
28	AB	*A. barbata*	2682	399	147	779
28	AB	*A. lusitanica*	30			
28	AB	*A. vaviloviana*	248	64	62	104
28	AB?	***A. agadiriana***	**37**	**7**	**2**	**29**
28	AC	***A. insularis***	**14**		**1**	**2**
28	AC	***A. magna (syn. A.maroccana)***	255	64	33	92
28	AC	***A. murphyi***	**85**	**19**	**5**	**22**
E) Wild relatives in the tertiary gene pool (diploid species)						
14	A	***A. atlantica***	**41**	**12**	**2**	**35**
14	A	*A. canariensis*	70	50	14	28
14	A	***A. damascena***	**28**	**17**	**13**	**26**
14	A	*A. hirtula*	105	44	18	44
14	A	*A. longiglumis*	103	38	19	41
14	A	***A. prostrata***	**2**	**13**	**2**	**14**
14	A	*A. wiestii*	82	32	23	36
14	C	***A. bruhnsiana***	**1**	**4**	**2**	**2**
14	C	*A. clauda*	126	32	16	34
14	C	*A. pilosa (syn. A. eriantha)*	156	27	15	33
14	C	***A. ventricosa***	**13**	**11**	**4**	**11**

Large collections of wild species are known to be held by PGRC Canada (15,134 accessions, 21 species), USDA-ARS (10,516 accessions, 10 species), The VIR collection (2003 accessions, 21 species), the Lieberman collection in Israel (1544 accessions, 7 species, mainly *A.sterilis*), the Moroccan collection (628 accessions, 13 species), the IPK collection (625 accessions, 14 species)[1], the Australian Winter Cereals Collection

[1] Currently the IPK revises taxonomic determination for all accessions taken over from the former BAZ genebank. Thus less determined species will be found in the official databases. Figures found here recur to elder information.

(545 accessions, 3 species), the Turkish collection (311 accessions, 4 species), the British John Innes collection (261 accessions, 11 species) and the Spanish collection (244 accessions, 6 species). Additional collections with remarkable species diversity, though lower numbers of respective accessions are the IHAR collection (97 accessions, 11 species) and the National Wheat Research Centre in Brazil (136 accessions, 9 species). The IGER collection (Welsh Plant Breeding Station) has listed 172 accessions of 19 species in elder data sources (EADB, Bioversity Directory), but only 9 accessions of 6 species are still listed in a recent EURISCO download.

Table 4 shows species, which are rare *in situ* and *ex situ* and the number of accessions of these species in some genebanks. It shows that the Moroccan genebank holds most accessions of *A.damascena*, *A.atlantica*, *A.agadiriana*, *A.murphyi* and *A.magna*; the Canadian genebank holds most of *A.canariensis*, *A.abyssinica* and *A.vaviloviana*.

Table 4 Number of accessions of endemic and rare wild *Avena* species

			PGRC	GBR016	RUS001	MAR071	DEU146	USDA
Endemic and locally rare	*A.damascena*	Syria, Morocco	3	9	5	**11**		
	A.macrostachya	Algeria	1		1			
	A.atlantica,	Morocco	15	10	2	**23**		
	A agadiriana	Morocco	14	5	4	**19**		
	A.murphyi	S-Spain	2	13	4	**73**	2	1
Endemic and locally common	*A.canariensis*	Canary Islands, Morocco	**45**	21	7		7	
	A.abyssinica	Ethiopia, Saudi Arabia,	**254**	67	52		8	241
	A.vaviloviana	Ethiopia	**134**	15	46			43
	A.magna	Morocco	34	17	16	**141**	34	2
Restricted, locally common	*A.hirtula*	Algeria, Morocco, Spain	**51**	14	13	30		

d) Morphological groups within *A.sativa*

Subspecific concepts in taxonomy and their usefulness in genetic resources work are under heavy dispute. They have been extensively elaborated and used down to the botanical variety level in Eastern European genetic resources work under the lead of the Vavilov institute. A useful summary has been made available to the ECPGR by Loskutov (1998). Yet reduced budgets for genetic resources work and diminishing availability of taxonomically skilled staff makes the use of these concepts increasingly difficult. In St.Petersburg, A. Diederichsen presented a concept of morphological groups, partially based on the Russian concepts. Based on three phenologic and 34 morphological characters, from theoretically 576 character state combinations (morphological groups) 118 could be found in the entire *A.sativa* collection of PGRC, Canada. Ten morphological groups were represented in 126 Canadian cultivars. Most accessions were represented in very few morphological groups.

He suggested three types of common cultivated oats to be treated at the subspecies level:

1. The common hulled oat *A.sativa* L. subsp. *sativa* Rod. representing 9378 (92%) of the USDA, 8754 accessions (75%) of the Canadian, 8729 accessions (80%) of the Russian, but only 1525 accessions (47%) of the Chinese *A.sativa* collection.
2. The hull-less oat *A.sativa* L. subsp. *nudisativa* (Husn.) Rod. et Sold., represented by 183 accessions (1.5%) in the Canadian, by 154 accessions (1.4%) in the Russian, by 326 accessions (3.2%) in the USDA but by 1699 accessions (53%) in the Chinese *A.sativa* collection. Studies by Boland and Lawes (1973), Oughan *et al*. (1996) and Koeyer *et al*. (2004) point to a single, incompletely dominant gene (N1) interacting with modifying genes to result in the hull-less condition. Also Fu *et al*. (2005), based on molecular studies questioned the independent development of hull-less oats because of their close molecular similarity to the hulled forms (see section II).

3. The red oat *A.sativa* L. subsp. *byzantina* (C.Koch) Romero Zarko, represented by 1168 accessions (10%) in the Canadian, by 1398 (13%) in the Russian and by 1115 accessions (11%) in the USDA *A.sativa* collection.

V. Results of a survey

Concepts and development of a survey to update information on responding collections are described in Appendix V.

a) Response to the survey

Quick surveys were sent out to get first contact to responsible institutions in many countries. It was assumed, a very detailed survey would not work for this purpose. A list of respondents to quick surveys is listed in Appendix IV. The response to the quick surveys was relatively low (Table 5, eight responses). Countries, whose representatives had already responded to the quick survey, e.g. Portugal, in most cases did not further respond to a detailed survey, which was sent to curators indicated in the quick survey. Thus in later stages of the study, the quick survey was given up and only detailed surveys were distributed.

Table 5 Responses to quick surveys as email attachment in MS Word format

Quick Surveys					
Return		Institution	Respondent	Oat curator	Pages
22.05.06	ISR002	Agricultural Research Organization, Volcani Center, Israel Gene Bank for Agricultural Crops	Rivka Hadas	Rivka Hadas	
26.05.06	PRT001	Banco Portugues de Germoplasma Vegetal	Ana Maria Barata	Ana Maria Barata	
30.05.06	URY003	Instituto Nacional de Investigación Agropecuaria, Estación Experimental La Estanzuela	Federico Codon	Monica Rebuffo	
08.06.06		APTA – Polo Regional Desenvolvimento Tecnologico dos Agronegocios	Jairo Lopes de Castro	Jairo Lopes de Castro	
16.06.06	PRT004	Department of Genetic Resources and Breeding, Genebank	Eliseu Bettencourt	Eliseu Bettencourt	
16.06.06	PRT005	Estacao de Melhoramento de Plantas	Benvido Martins Macas	Benvido Martins Macas	
15.09.06	PAK001	Plant Genetic Resources Programme (PGRP), Institute of Agri-biotechnology & Genetic Resources (IABGR), National Agricultural Research Centre (NARC)	Muhammad Afzal	Muhammad Afzal	
26.09.06	JOR006	National Centre for Agricultural Research and Technology Transfer	Ziad Tahabsom	Ziad Tahabsom	

Detailed surveys were sent out to genebank curators to update relevant information on the structure and management of the collections. A list of respondents to detailed surveys is listed in Appendix IV. Twenty-three curators responded to the detailed survey in text format as email attachment (Table 6). Additionally Seeds of Diversity, Canada and the Federal Agronomic Research Station of Changins, Switzerland (CHE001) responded that they have no *Avena* accessions in their collections. The detailed survey was also available as an online questionnaire. The online questionnaire was used by 11 respondents. It was not the preferred form and often very incompletely filled by the respondents. In three cases the respondents gave up with the online survey and sent an additional survey as an email attachment. In total 38 institutions contributed to the surveys. It is obvious from Tables 5-8, that it took considerable time to get response to the surveys. First replies from quick surveys were received end of May 2006. The detailed survey was started with making the online version productive in the mid of June 2006. First responses were received in the online version at the end of June; last responses were received at the beginning of December 2006. Response to the text survey was slow as well. By the time of the first meeting in Fargo at the end of July 2006 only 16 detailed surveys were available. The latest survey was sent by email in February 2007. In many cases repeated contacts were necessary to get curators responding.

Table 6 Collections, which responded to the detailed surveys as email attachment in MS Word format

Detailed Surveys						
Return		Institution	Respondent	Oat curator	Pages
26.06.06	CAN004	Agriculture and Agri-Food Canada, Plant Gene Resources of Canada, Saskatoon Research Centre	Axel Diederichsen	A. Diederich-sen	
28.06.06	SWE002	Nordic Gene Bank	Louise Bondo	L. Bondo	
03.07.06	NLD037	Centre For Genetic Resources, The Netherlands (CPRO-DLO)	Noor Bas	N. Bas	
04.07.06	ROM007	Suceava Genebank	Danela Murariu	D. Murariu	
17.07.06	BGR001	Institute for Plant Genetic Resources `K.Malkov`	Nadejda Antonova	N. Antonova	
17.07.06	BRA003	Embrapa Recursos Genéticos e Biotecnologia	Clara Oliveira Goedert	C.O. Goedert	
17.07.06	ISR003	Tel-Aviv University Institute Cereal Crop Development Lieber-man Germplasm Bank	Jacob Manisterski	J. Manisterski	
19.07.06	URY003	Instituto Nacional de Investigación Agropecuaria, Estación Experimental La Estanzuela	Federico Codon	Monica Rebuffo	
21.07.06	ECU077	Instituto Nacional Autónomo de Investigaciones Agropecuarias, Departamento Nacional de Recursos Fitogenéticos y Biotec-nología, Estación Experimental Santa Catalina	Alvaro Monteros	Cesar Tapia	
25.07.06	RUS001	N.I. Vavilov Research Institute of Plant Industry	Igor Loskutov	I.Loskutov	
25.07.06	UKR001	Yurjev Plant Production Institute, National Centre for Plant Genetic Resources of Ukraine	Victor Ryabchoun	Oleg Illichov	
22.08.06	DEU146	Leibnitz-Institute of Plant Genetics and Crop Plant Research	Andreas Boerner	A. Boerner	
20.09.06	CHN001	CAAS-Bioversity Centre of Excellence for Agrobiodiversity, c/o Institute of Crop Science of the Chinese Academy of Agricul-tural Sciences	Zongwen Zhang	Z. Zhang	
03.10.06	USA029	USDA-ARS, National Small Grains Collection	Harold Bockelman	H. Bockelman	
20.10.06	AUS003	Agricultural Research Centre, Australian Winter Cereals Collec-tion	Michael Mackay	M. Mackay	
03.11.06	ITA037	Istituto Sperimentale per la Cerealicoltura	Rita Redaelli	R. Redaelli	
08.11.06	TUR001	Aegean Agricultural Research Institute, Department of Plant Genetic Resources	Ayfer Tan	A. Ertug Firat	
09.11.06	MNG001	Plant Science Agricultural Research and Training Institute	Noov Bayarsukh	J. Namjilsuren	
24.11.06	AUT001	Austrian Agency for Health and Food Safety Ltd., Business Area Agriculture / Seed Collection	Paul Freuden-thaler	Wolfgang Kainz	
06.12.06	KEN101	Plant Genetic Resources Centre, National Genebank of Kenya	Peterson W. Wambugu	Zachary K. Muthamia	
12.12.06	ETH013	International Livestock Research Institute	Jean Hanson	Jean Hanson	
28.12.06	POL003	National Plant Genetic Resources Centre Plant Breeding and Acclimatization Institute	M. Chojnowski	Zofia Bulin-ska-Radomska	
05.02.07	MAR071	Institut National de la Recherche Agronomique (INRA), Mo-rocco	Nezha Saidi	Nezha Saidi	

Tow additional factors that contributed to the slow and low response have to be taken into consideration: contact information available in the internet is mostly not up to date and changing very frequently. Keeping databases of contact information up to date seems to be one of the big challenges for genetic resources documentation; email is increasingly deteriorating as a safe contact medium by the increasing flood of junk mails and resulting measures to be taken against this. Email from unknown senders is probably most likely filtered out as junk. Difficulties and delays to be expected with such questionnaires will have to be considered in the scheduling of further crop strategies. The deadline of this project has been repeatedly broken because of these difficulties, which caused further difficulties in availability of working capacity and organizational issues.

Table 7 Additional databases and Excel sheets provided with the survey

Return		Institution
03.07.06	NLD037	Centre For Genetic Resources, The Netherlands (CPRO-DLO)
12.07.06	CAN004	Agriculture and Agri-Food Canada, Plant Gene Resources of Canada, Saskatoon Research Centre
20.07.06	USA029	USDA-ARS, National Small Grains Collection
03.08.06	EST001	Jogeva Plant Breeding Institute
20.10.06	AUS003	Agricultural Research Centre, Australian Winter Cereals Collection
06.12.06	KEN101	Plant Genetic Resources Centre, National Genebank of Kenya

Table 8 Collections which responded to the detailed surveys available on the Internet

Online Surveys					
Return		Institution	Oat curator	Respondent	Pages
20.06.06	AUS002	South Australian Research & Development Institute (SARDI)	Pamela Zwer	Pamela Zwer	
21.06.06	GBR004	Millennium Seed Bank Project, Seed Conservation Sect. Royal Botanic Gardens, Kew	Simon Lining-ton	Janet Terry	
04.07.06	EST001	Jogeva Plant Breeding Institute	Külli Annamaa	Külli Annamaa	
05.07.06	BRA003	Embrapa, Centro Nacional de Pesquisa de Trigo (CNPT)	Edson Jair Iorczeski	Edson Jair Iorczeski	
06.07.06	FRA040	Institut National de la Recherche Agronomique (INRA), Station d'Amelioration des Plantes	Jean Koenig	Jean Koenig	
11.07.06	GBR165	Scottish Agricultural Science Agency	Rachel Tulloch	Rachel Tulloch	
13.07.06	URY003		Monica Re-buffo	Federico Con-don	
20.09.06	JOR006	National Center for Agricultural Research and Tech-nology Transfer	Ziad Tahab-som	Ziad Tahab-som	
20.09.06	MNG001	Mongolian State University of Agriculture			
03.10.06	PER002	Universidad Nacional Agraria	Luz Gomez-Pando	Luz G¢mez-Pando	
04.12.06	GBR016	Institute of Grassland & Environmental Research	Ian D. Thomas	Ian D. Thomas	

b) Introduction of the collections, who have responded or participated in meetings – objectives and main impacts

The South Australian Research and Development Institute (AUS002) considers itself a breeding collection. Also the role of the Australian Winter Cereals Collection is primarily seen as a service to oat research, in Australia and overseas, through acquisition, documentation, quarantine, multiplication, distribution and long term storage. The collection responds to breeders and pre-breeders. Currently there is little activity as there seems to be a decline in the investment in oat breeding and research.
The Austrian Agency for Health and Food Safety Ltd. (AUT001) has a seed collection targeted to long-term conservation, but also acting as a working collection, to provide genotypes adapted for the regional climate and with disease resistance. But the material is not yet evaluated.
The Institute for Plant Genetic Resources `K.Malkov` (BGR001) sees the main importance of its collection in providing genotypes for cold tolerance, adaptation to a short vegetative period and high productive potential. An important part is spring and winter naked oats.
The collection of Embrapa Recursos Genéticos e Biotecnologia (BRA003) is primarily dedicated to long-term conservation, while the collection of the National Wheat Research Center (BRA015) is basically a working and breeding collection. Black oat (*A.strigosa*) is the most widely distributed oat in the country. It is used for animal,

as pasture and mostly year after year it comes as volunteer crop following soybean or maize grown in the summer. Therefore, there is room for genetic improvement.
The Plant Gene Resources of Canada (CAN004) has been given the role of a World Base Collection by the former IBPGR. It acts in long term conservation, as a working collection, a source for breeding and research at the national and international level. The PGRC collection is comprehensive, recently regenerated seeds are available and characterisation data is accessible.
The collection of the Chinese Academy of Agricultural Sciences, Institute of Crop Germplasm Resources (CHN001) acts as long-term and working collection. Oats are recognized as functional food in China with high development potential. The oat collection is crucial for breeding activities. It will be the sources of useful genes for resistance to pests and disease, high yielding, high quality, etc.
The collection of the Institute for Plant Genetics and Crop Plant Research (DEU146) is primarily dedicated to long term conservation.
The collection of the Estación Experimental Santa Catalina (ECU077) is a long term conservation and breeding collection.
The Centro de Recursos Fitogeneticos (ESP004) has been presented by P.Garcia in St.Petersburg. It conserves primarily (77%) Spanish landraces, which have been collected in the 1930s and 1940s.
The collection of the Jogeva Plant Breeding Institute (EST001) is also dedicated to long-term conservation. Its mandate is to conserve mainly the material of Estonian origin, but it is also used as a breeders' collection. The focus is on natural disease resistance, to avoid the use of chemical disease treatment, genotypes well adapted to local ecological conditions and bred for low input agriculture.
The collection of the International Livestock Research Institute (ETH013) acts in active and long term conservation, distribution of germplasm and in selection of superior genotypes for livestock feed. The germplasm were identified by ICARDA staff as having good potential for forage oats.
The INRA collection in the Station d'Amelioration des Plantes (FRA040) has been a working collection. As there is no oat breeding or research anymore at INRA or at French breeders, this collection is more dedicated to patrimony conservation and a little to be used in European evaluation programs. Significant results of breeding work at INRA resulted in a nice collection of breeding lines. Breeding work included disease and frost tolerance.
The Millennium Seed Bank Project at Kew Royal Botanic Gardens (GBR004) maintains a collection for long-term conservation. It is available for distribution for bona-fide research, reintroduction, restoration.
The collection of the Scottish Agricultural Science Agency (GBR165) is dedicated to long term conservation of varieties of importance to Northern Britain. Currently it is able to supply landraces only.
The Lieberman Germplasm Bank (ISR003) is a long term conservation and working collection. It concentrates on use of *A.sterilis* for disease resistance breeding. This hexaploid species is easily crossed with *A.sativa*.
The Istituto Sperimentale per la Cerealicoltura, Bergamo (ITA037) maintains a collection in medium-term conservation for a) conservation of genetic resources; b) utilization of accessions in breeding programs; c) genetic studies on chemical components of the kernel (protein, soluble fiber). It is interested in genotypes from other countries to improve the agronomic and technological characteristics of own cultivars. Interspecific crosses are used to study the genetic control of some proteins.
The National Centre for Agricultural Research and Technology Transfer (JOR006) has been included in the questionnaire as located in a region considered as a diversity centre. They responded to have a herbarium sample only, but not any seed collection of oat in the genebank so far.
The National Genebank of Kenya (KEN101) is dedicated to long term conservation.
The collection of INRA Morocco (MAR071) is targeted to the collection of plant genetic resources for characterisation, breeding and conservation for long and medium terms. Most of the collected material has shown some agronomic traits of high economic value such as the high protein content in the groat of some tetraploid species, resistance to drought and to some diseases which threaten oat cultivation.
The collection of the Plant Science Agricultural Research and Training Institute (MNG001) is dedicated to long term conservation. Oat germplasm is to be used for oat improvement research programs, which are targeted to drought tolerance, resistance to loose smut, yellow rust, stem rust resistance and high oil content in the seed.
Also the Centre For Genetic Resources, The Netherlands (NLD037) is dedicated to long term conservation. The collection is mainly used for research.
The New Zealand Institute for Crop and Food Research Limited (NZL027) has maintained a collection of oat lines since the early 1950's. The base collection of 721 oat lines is maintained under long term storage condi-

tions. A working collection of recently developed oat lines is also maintained by the breeder as a source of genes for winter adaptation in New Zealand and disease resistances.
The collection of the Universidad Nacional Agraria (PER002) is preserved in the university since 1970. The material was evaluated in the highlands of Peru and some genotypes were selected mainly for forage production.
The National Plant Genetic Resources Center at IHAR (POL003) maintains a collection for long-term conservation. Base collection and active collection are maintained under long-term storage conditions. It functions as a source of genes for diseases resistance, winter hardiness and adaptation to unfavorable weather conditions.
The Suceava Genebank (ROM007) is targeted to the preservation of the autochthon collection (long-term conservation, working collection) and to provide material with high level of resistance to biotic and abiotic factors to Romanian plant breeding programs. The oat collection can be used by breeders especially those who work in oat breeding programs for resistance to biotic and abiotic stress.
The N.I. Vavilov Research Institute of Plant Industry (RUS001) oat collection comprises long-term conservation, a working collection (in non-controlled condition), short-term conservation, breeding collection and genestock collection. The VIR world oat collection includes landraces, local varieties, advanced cultivars, breeding material, and gene stocks lines.
The Nordic Gene Bank (SWE002) is an inventory of Nordic cultivars and landraces performing also evaluation and characterisation of accessions in long term conservation. It has the long term responsibility for all oat accessions of Nordic origin. Passport, evaluation and characterisation data are published on internet. The Nordic oat collection attracts interest by oat breeding all over the world and has contributed to breeding and research programs several times.
The Aegean Agricultural Research Institute, Department of Plant Genetic Resources (TUR001) is engaged in *ex situ* conservation of working collections of breeders landraces and wild related species in both medium-term and long-term conditions. The main potential and importance of the oat collection in AARI Gene Bank is that oat accessions have potentially many diverse genes to be used in breeding.
The collection of the Ustymivka Experimental Station of Plant Production (UKR008) is dedicated to long-term conservation. It is further a collection of important traits, a working (= breeding) collection, and an educational collection. It contains genetic stocks of economic valuable traits for breeding, i.e. adaptation to the conditions of different natural-climatic regions of Ukraine, productivity, resistance to diseases, grain quality and others.
The collection of the Estación Experimental La Estanzuela (URY003) is a long term and working collection. It can be a very interesting source of disease resistance genes in an adapted background.
The USDA-ARS, National Small Grains Germplasm Research Facility (USA029) maintains worldwide diversity, especially a large collection of *A. sterilis* with rust resistance.

c) Legal status, claimed ownership and perceived relationship to the International Treaty

Table 9 lists statements given in the questionnaire regarding status of the collection, ownership and relationships to the International Treaty (IT). Most collections are affiliated with the national governments, only few with universities or international organizations. None of the collections, who responded, was in private hands. The Australian Winter Cereals collection seems to be primarily funded from private hand, which causes difficulties in the definition of ownership and the relationship to the IT.
Most of the institutions claim ownership of their collection. In Germany and Sweden they keep the collection in trust for their national or regional program. Netherlands representatives explicitly state, that no ownership at all is claimed for their collection. The Ethiopian International Livestock Research Institute (ETH003) considers it as global public goods under purview of the Treaty.
Some collections do not consider themselves subject to the IT. These are the Chinese Academy of Agricultural Sciences (CHN001), the Scottish Agricultural Science Agency (GBR165), the Lieberman Germplasm Bank (ISR003), the Istituto Sperimentale per la Cerealicoltura, Bergamo (ITA037), the Universidad Nacional Agraria La Molina (PER002), the N.I. Vavilov Research Institute of Plant Industry (RUS001) and the Ustymivka Experimental Station of Plant Production (UKR008). In Tables 36, 38 and 40 can be found, whether countries have ratified the Treaty. China, Israel, Russia, USA, Ukraine, Japan and both Koreas have not ratified, whereas UK, Italy and Peru have.

Table 9 Status and legal frameworks of the collections, which participated in the questionnaire

INSTITUTION		STATUS	Ownership claimed		International Treaty	
				Explanation	subject to	Submission planned
AUS002	South Australian Research and Development Institute	Government	Yes			
AUS003	Agricultural Research Centre, Australian Winter Cereals Collection	Government	Unclear	hosted by state government, funded by industry	Yes? (but only government)	
AUT001	Austrian Agency for Health and Food Safety Ltd, Seed Collection	Government	Yes		Yes, pending	
BGR001	Institute for Plant Genetic Resources `K.Malkov`	Government	Yes		Yes	
BRA003	Embrapa Recursos Genéticos e Biotecnologia	Government	Yes		Yes	
BRA015	National Wheat Research Center	Government	Yes		Yes	
CAN004	Agriculture and Agri-Food Canada, Plant Gene Resources of Canada	Government	Yes		Yes	
CHN001	CAAS, Institute of Crop Germplasm Resources	Government	Yes		**No**	
DEU146	Institute for Plant Genetics and Crop Plant Research – Genebank	Government	No	IPK Genebank keeps in trust	Yes	
ECU077	Estación Experimental Santa Catalina	Government	Yes		Yes	
EST001	Jogeva Plant Breeding Institute	Government	Yes		Yes	
ETH013	International Livestock Research Institute	CGIAR Centre	No	Global public goods under purview of the Treaty	Yes	
FRA040	INRA, Station d'Amelioration des Plantes	Government	Yes		Yes	
GBR004	Millennium Seed Bank Project, Royal Botanic Gardens, Kew	Government	Yes			
GBR165	Scottish Agricultural Science Agency	Government	Yes		**No**	**Not planned**
ISR003	Lieberman Germplasm Bank	University	Yes		**No**	
ITA037	Istituto Sperimentale per la Cerealicoltura, Bergamo	Government			**No**	
KEN101	Plant Genetic Resources Centre, National Genebank of Kenya	Government	Yes		Yes	
MAR071	INRA Morocco, Breeding Unit, Forage Laboratory	Semi-governmental	Yes		Yes	
MNG001	Plant Science Agricultural Research and Training Institute	Government	Yes		Yes	
NLD037	Centre For Genetic Resources, The Netherlands (CPRO-DLO)	Government	No	No ownership (at all) claimed	Yes	
PER002	Universidad Nacional Agraria La Molina		Yes		**No**	**Not planned**
POL003	National Plant Genetic Resources Centre Plant Breeding and Acclimatization Institute	Government	Yes		Yes	
ROM007	Suceava Genebank	Government	Yes		Yes	
RUS001	N.I. Vavilov Research Institute of Plant Industry	Government	Yes		**No**	
SWE002	Nordic Gene Bank	Government	No	Collection owned by national (regional?) program	Yes	
TUR001	Aegean Agricultural Research Institute, Department of Plant Genetic Resources	Government	Yes		Yes	
UKR008	Ustymivka Experimental Station of Plant Production	Government	Yes		**No**	
URY003	Instituto Nacional de Investigación Agropecuaria, Estación Experimental La Estanzuela	Government	Yes		Yes	
USA029	USDA-ARS, National Small Grains Germplasm Research Facility	Government	Yes		Yes	

d) Proportion of accessions of national (and where known, regional) origin or introduced from elsewhere

Table 10 shows an estimation of national, regional, collected vs. introduced origin as given by the curators in the questionnaire (detailed survey). In many cases it is difficult to trace the actual origin of the accessions. Thus these figures have been given approximately (e.g. explicitly stated by the Canadian curator) and there may be slight differences to total values as given in other tables. For Bulgaria 300 accessions of Bulgarian breeding and research materials have not been included in the list of nationally originating accessions but have been included to the collection in other parts of the questionnaire.

Table 10 Origin of the collections, which participated in the questionnaire (number and percentage of the accessions)

FAOCODE	Total	National		Regional		Collected		Introduced	
		Number	%	Number	%	Number	%	Number	%
USA029	21834	6992	32				100	14202	65
RUS001	12155	3048	25	1675	14	869	7	6563	54
CHN001	3257	2234	**69**					1023	31
CAN004	26820	1784	7			7411	28	17624	65
ISR003	1844	1500	**83**	300	17				
MAR071	690	552	**80**					138	20
DEU146	4758	480	10					2315	49
ECU077	544	428	**79**					9	2
POL003	2095	306	15					1316	63
ROM007	180	174	**97**	125	**69**			5	3
AUT001	256	109	43	134	**52**			2	1
UKR008	623	98	16	2	0,3			508	**82**
NLD037	536	78	15	260	49			172	32
ITA037	714	49	7					665	**93**
MNG001	1358	46	3					1304	**97**
BRA015	337	22	7	18	5			309	**92**
EST001	131	14	11					117	**89**
KEN101	4196	11	0,3	3676	**88**				
GBR004	35	3	9						
TUR001			**100**						
GBR165			**100**						
FRA040			**84**						16
AUS002			**80**						20
PER002			5						**95**
AUS003	4602					2577	56	667	14
BGR001	1740					22	1	1718	**99**
URY003			10		25				65
SWE002	321			314	**98**				
BRA003	512							512	**100**
ETH013	121							117	**97**

High percentages of accessions from **national origin** have been reported for the collections of the Aegean Agricultural Research Institute (TUR001), the Scottish Agricultural Science Agency (GBR165), the Station d'Amelioration des Plantes (FRA040), the Suceava Genebank (ROM007), the Lieberman Germplasm Bank (ISR003), the collection of INRA Morocco (MAR071), the South Australian Research and Development Institute (AUS002), the Estación Experimental Santa Catalina (ECU077) and the Chinese Academy of Agricultural Sciences (CHN001). In some cases, this may reflect a policy to restrict the national collections to accessions of national origin. Largest absolute numbers of accessions from national origin are present in the USDA collection (almost 7000), the VIR collection (more than 3000) and the Chinese collection (more than 2000). The Nor-

dic Gene Bank (SWE002) has a high proportion of accessions of regional (Scandinavian) origin. In the case of the Kenyan genebank the concept of regional origin might have been misunderstood. Provided data show a global origin.
Accessions introduced from other collections may be duplicates. But it may be unknown, whether the original accessions are still existing. A high percentage of those accessions has been reported by both Brazilian collections (BRA003 and BRA015), some Eastern European collections (BGR001, EST001, UKR008), which may reflect the still high duplication with the Vavilov institute or repatriation programs, the Ethiopian International Livestock Research Institute (ETH013), the Mongolian genebank (MNG001) the Universidad Nacional Agraria La Molina (PER002), and the Istituto Sperimentale per la Cerealicoltura, Bergamo (ITA037). The Mongolian genebank had germplasm exchange mainly with the USDA (622 accessions), the Vavilov institute (316), European genebanks (166) and the Republic of Korea (149). The Australian Winter Cereals Collections (AUS003) reported most of the material collected. This material was provided by breeders, which collected it *in situ* abroad. 1200 accessions are maintained as a black box storage service. They are not publicly available.

e) Perceived uniqueness of the collections

Table 11 shows the perception of uniqueness of their collections by the respondents of the questionnaire. Full or dominating uniqueness, based primarily on national or regional origin of the accessions is reported by the Nordic Gene Bank (SWE002), the Aegean Agricultural Research Institute (TUR001), the Lieberman Germplasm Bank (ISR003) and the collection of INRA Morocco. Morocco, Turkey and Israel are in centres of diversity of the genus. Some tetraploid species endemic to Morocco (*A.magna*) are of special interest. In some cases, the perception of uniqueness is based on a special role collections played in the history of collecting. The Canadian collection has been assigned the status of a World Base Collection by IBPGR in 1976. About 27% of the collection resulted from comprehensive collecting with a broad coverage of the genus and with emphasis on wild species and landraces of *A.sativa* subsp. *byzantina* during the 1960s and 1970s by F.J. Zillinsky, B.Baum, T.Rajhathy and J.W.Martens co-operating with partners in the Mediterranean, the Near East and Ethiopia. The collection has been widely used in oat breeding. By activities to maintain a backup-collection representing the entire *Avena* gene pool duplicates from several genebanks, especially the USDA and Nordic genebank, have been integrated into the active collection during the 1980s. This resulted in a duplication of 17561 accessions from the USDA in the PGRC collection (68% of the PGRC collection). Duplication of Scandinavian accessions with the Nordic Genebank is of low number. PGRC is ready to continue playing a leading role in oat genetic resources work. Confirmation and further clarification of the current role of the World Base Collection concept has been requested. It has been confirmed by the assignment of the coordinating role in a World Oat Diversity Network to PGRC.
The Vavilov collection derives its uniqueness from collecting activities initiated by N.I.Vavilov in the 1920s and 30s and ongoing through the 1940s and 1950s. Mainly local varieties have been collected. The origin of the collection is predominantly Europe, with a great proportion of Russian material. Other large parts originate from North America and Asia, small parts from Africa, South America and Australia. Genes, mainly for resistances have been identified in many accessions. Some accessions have multiple interesting alleles. Characterisation and evaluation data, mainly on crown rust, stem rust, Helminthosporium blight and BYDV are available from eight stations from the most Northern to the most Southern parts of Russia. The collection is also evaluated for biochemical characters as protein, amino acid composition, starch, ß- glucan, oil, fatty acids, tocopherols and sterols.
The Institute for Plant Genetics and Crop Plant Research (DEU146) has a similar long tradition of collecting starting in the 1940s, mainly in Eastern Europe. Other collections see their uniqueness based on a dedicated focus in their work, e.g. the Lieberman Germplasm Bank on their focus on local *A.sterilis* material.
The Embrapa Recursos Genéticos e Biotecnologia (BRA003) and the International Livestock Research Institute (ETH013) consider themselves fully duplicated.
All other collections claim partial uniqueness. In many cases, this perception is based on the part of landrace and obsolete cultivar accessions from their own countries (e.g. Austria, Estonia, France, Northern Britain, Italy, Netherlands, Poland, Romania, Ukraine, Uruguay) and reflects the currently predominating patrimony approach to genetic resources. It not necessarily reflects a high percentage of national origin in the respective collections (cf. EST001, ITA037, NLD037, POL003, UKR008, URY003). Awareness is necessary, that these collections may follow a trend to further reduce their foreign material, though it is not always ensured, that similar accessions are still available in their countries of origin.

Table 11 Perception of the uniqueness of collections by the respondents of the questionnaire

SWE002	Full	Quite good passport documentation of the accepted accessions
TUR001	Full	Since Turkey is centre of origin for many *Gramineae* including oats, the fact that the oat collection has a broad genetic diversity makes it unique.
DEU146	Mostly	
ISR003	Mostly	***Avena sterilis*** is wide-spread over all the country, in different geographical areas and soil types. It is very rich in **crown rust resistance** and oat **stem rust slow rusting**. It may contain more traits for future use.
MAR071	Mostly	A much diversified collection. It contains some **endemic species to Morocco** such as ***A.magna***, ***A.agadiriana***, etc. which are unique in the world.
RUS001	Mostly	World's **landraces** diversity **collected** by Vavilov and his colleagues **before Second World War**
AUS003	Partial	Our acquisitions and holdings almost completely **reflect the interests of breeders** and pre-breeders. There is no plant genetic resources research associated with the collection.
AUT001	Partial	**Traditional and old landraces locally adapted**
BGR001	Partial	Obsolete improved varieties
BRA015	Partial	It can be used as sources of variability for the breeding program.
CAN004	Partial	**Size and species diversity; World base collection**
EST001	Partial	Obsolete varieties of **Estonian origin**.
FRA040	Partial	Most interesting is the number of **French landraces representing the history of French oats**. I am still introducing sometimes a few French landraces from prospecting.
GBR165	Partial	**Each variety covered is fully described**. Each variety **has agronomic test data**. The collection covers **Northern Britain only**.
ITA037	Partial	Our collection, in spite of the number of entries which is not large, contains a number **of Italian genotypes and cultivars** which maybe are not present in the collection of other countries, due to the reduced diffusion of our oat germplasm
MNG001	Partial	**Resistance** to grain shattering, lodging and diseases
NLD037	Partial	It contains **Dutch landraces and old varieties and research material with known ancestors** from Dutch breeding program.
POL003	Partial	Good representation of **Polish landraces** and some wild species collected during expeditions. ***A. macrostachya*** as valuable source of winter hardness.
ROM007	Partial	The oat collection from the Suceava Genebank comprises the **local landraces** which are very **resistant to low temperatures and to the foliar diseases**
UKR008	Partial	The **cultivars from home country** (Ukraine)
URY003	Partial	The most interesting part of the collection is the **local landraces**. We have found differences in cycle, growing habit and disease resistance mainly to aphids.
USA029	Partial	
CHN001	Not Specified	The most unique traits are **naked grain type**, **resistance to drought**, **adaptability to marginal environments**
ECU077	Not Specified	From the breeding materials (working collection), the breeder has selected the best materials to keep them in the genebank
KEN101	Not Specified	The accessions have not been characterised or evaluated hence their uniqueness and potential value is not known
BRA003	Fully duplicated	
ETH013	Fully duplicated	The collection is mostly a duplication of the ICARDA collection and as such is not unique.

f) <u>Proportion of accessions of wild related species</u>

Table 12 shows numbers of accessions for wild and cultivated species and the total number of accessions as given by the respondents in the questionnaire. The hexaploid species *A.sativa* and *A.byzantina* were considered as cultivated species, while all others were considered as wild (or marginally cultivated) species. Marginally cultivated species are *A.abyssinica* and *A.strigosa* including *A.nuda* L. and *A.brevis*. PGRC, Canada reported also of wild or weedy *A.sativa* (56 accessions). PGRC Canada has the largest collection of *Avena* with almost 27,000 accessions. It has also the largest collection of wild species with almost 15,000 accessions. USDA has the second largest collection with almost 22,000 accessions, almost 10,500 of them from wild species. It follows the Russian collection with 12,000 accessions (2000 wild), the IPK collection with almost 4800 accessions, the Australian Winter Cereals Collection with 4600 accessions, almost 550 of wild species, and the Kenyan collection with 4200 accessions, most of the considered to be landraces.

Table 12 Number of accessions from wild and cultivated species as reported by the participants of the questionnaire

INSTITUTION		Wild[1]	Cultivated		Un-known[2]	Total
			marginally	sativa		
Agriculture and Agri-Food Canada, Plant Gene Resources of Canada, Saskatoon Research Centre	CAN004	**14462**	**473**	11613	272	26820
USDA-ARS, National Small Grains Germplasm Research Facility	USA029	**10507**	**391**	10924	12	21834
N.I. Vavilov Research Institute of Plant Industry	RUS001	**1955**	**252**	9905		12112
Institute for Plant Genetics and Crop Plant Research - Genebank	DEU146	**238**	**62**	2669	1789	4758
Australian Winter Cereals Collection	AUS003	**545**	4	238	3814	4601
Plant Genetic Resources Centre, National Genebank of Kenya	KEN101	8		4188		4196
CAAS Institute of Crop Germplasm Resources	CHN001	31		3224		3255
IHAR National Plant Genetic Resources Centre	POL003	**97**	**71**	1927		2095
Institute for Plant Genetic Resources `K.Malkov`	BGR001	5	19	2013		2037
Lieberman Germplasm Bank	ISR003	**1544**		300		1844
CRF, Banco de Germoplasma Vegetal	ESP004	**244**	**23**	1293	47	1607
Plant Science Agricultural Research and Training Institute	MNG001	3	7	1348		1358
APTA – Polo Regional Desenvolvimento Tecnologico dos Agro-negocios	*BRAAPTA	3		1158		1161
Institut National de la Recherche Agronomique (INRA), Station d'Amelioration des Plantes	FRA040	4	7	877		888
Instituto Nacional de Investigación Agropecuaria, Estación Experimental La Estanzuela	URY003		**18**	835		853
Aegean Agricultural Research Institute, Department of Plant Genetic Resources	TUR001	**311**		492		803
Institut National de la Recherche Agronomique de Tunisia	TUN001	**92**	6	632		730
Istituto Sperimentale per la Cerealicoltura, Bergamo	ITA037	10	3	697		714
INRA, Breeding Unit, Forage Laboratory	MAR071	**628**		62		690
Scottish Agricultural Science Agency	GBR165	2	9	623		634
Ustymivka Experimental Station of Plant Production	UKR008	12	5	606		623
Estación Experimental Santa Catalina	ECU077		4	540		544
Centre For Genetic Resources, The Netherlands (CPRO-DLO)	NLD037	15	3	517	1	536
Embrapa Recursos Genéticos e Biotecnologia	BRA003	1	2	509		512
National Wheat Research Center	BRA015	**136**	**118**	78	5	337
Pakistan Plant Genetic Resources Programme	PAK001	(25)		298	25+2	323
Nordic Gene Bank	SWE002	7	4	310		321
Austrian Agency for Health and Food Safety Ltd., Business Area Agriculture / Seed Collection	AUT001		1	255		256
Agricultural Research Organization, Volcani Center, Israel Gene Bank for Agricultural Crops	ISR002	117		52		169
Estacao de Melhoramento de Plantas	PRT004			143		143
Jogeva Plant Breeding Institute	EST001			131		131
Suceava Genebank	ROM007			130		130
Banco Portuguese de Germoplasma Vegetal	PRT001			82		82
Department of Genetic Resources and Breeding, Genebank	PRT005	8		0		8

1 *A.sativa* and *A.byzantina* have been classified as cultivated, *A.abyssinica*, *A.brevis*, *A.hispanica*, *A.nuda* and *A.strigosa* as marginally cultivated all other species as wild species.
2 Interspecific hybrids or species unknown.

Additional big collections of wild species are located in the Lieberman Germplasm Bank (ISR003, mainly *A.sterilis*), in INRA Morocco, especially notable regarding the endemic and restricted species, in the Aegean Agricultural Research Institute (TUR001) and the Spanish collection (ESP004). In the South American region the Brazilian National Wheat Research Center has a considerable collection of wild and marginally cultivated species.

Table 13 Representation of wild and marginally cultivated *Avena* species in collections

Genebank	A.atlantica	A.brevis	A.canariensis	A.damascena	A.hirtula	A.longiglumis	A.nuda	A.strigosa	A.wiestii	A.clauda	A.pilosa	A.ventricosa	A.,macrostachya	A.abyssinica	A.barbata	A.vaviloviana	A.agadiriana	A.insularis	A.magna	A.murphyi	A.fatua	A.hybrida	A.ludoviciana	A.sterilis
CAN004	**15**	**39**	**45**	3	**51**	**45**	**19**	145	**46**	**91**	**132**	**5**	**1**	**254**	1685	135	**14**	**3**	**34**	**2**	579	**23**		11461
USA029		**22**				7	**8**	120	4		4			**241**	611	43			2	**1**	1322	**1**		8246
RUS001	2		**7**	5	**13**	**12**		200	**15**	**13**	**12**	**3**	**1**	**52**	96	46	**4**	**2**	**16**	**4**	221		435	1037
AUS003							3	1					**1**								7			536
KEN101																					8			
CHN001																			**21**		5			5
DEU146		6	**7**			5	4	44	5					8	40				**34**	**2**	96	1		65
POL003	1			**9**	6	1		70					**10**	1	3			**8**	1	**1**	20			37
BGR001		**7**						8						4	2						3			
ISR003					7	**10**			5	6	6				10									1500
ESP004						4		23							101					**1**	26			112
MNG001		2						3						2										3
FRA040		1						5						1									2	
URY003								18																
TUR001															32						71		4	204
TUN001							4	2										**2**						90
ITA037			1				1	2		1					1			**1**	2	**2**				2
MAR071	**23**			**11**	**30**	18			6	15		**5**			157		**19**		**141**	**73**	1			129
GBR165								9													1		1	
UKR008								4				**1**		1	1	2			1		2		1	3
ECU077								4																
NLD037		2						1													1		2	2
BRA003		1												1							1			
BRA015		**10**				5		58	1		2			50	50	22			3		1			52
SWE002								4													5			2
AUT001								1																

[1]Total collection including cultivated species

Table 14 Representation of wild *Avena* species in European collections indicated by EURISCO

	A.atlantica	A.brevis	A.canariensis	A.damascena	A.hirtula	A.longiglumis	A.nuda	A.strigosa	A.wiestii	A.clauda	A.pilosa	A.ventricosa	A.macrostachya	A.abyssinica	A.barbata	A.vaviloviana	A.agadiriana	A.insularis	A.magna	A.murphyi	A.fatua	A.hybrida	A.ludoviciana	A.sterilis	Total
RUS001	**2**		**7**	**4**	**12**	**11**		191	**17**	**13**	**12**	**4**	**1**	53	83	46	**2**	**1**	**14**	**3**	219		433	1045	11857
DEU146		**6**	**7**			**4**	**4**	35	**6**					6	35				**16**	**2**	90	1		54	2903
GBR011		**9**			**2**	**2**		46		1	1	**2**		67	11	15			1		63			75	2598
BGR001		**8**				1	**16**	12		1	1			5	7	1					19	1		6	2308
POL003				**9**	**6**	1	1	70						1	3						20			37	2274
CZE047								4						1							1		1	4	1984
ESP004								23																	1307
HUN003		4					**8**	20						3					**2**		29			10	1228
SVK001																					2				854
SWE002		2					**3**	6						2	2						5			5	726
ITA060								4							1						1			2	630
NLD037		2						1													1		2	2	536
UKR007																									319
AUT001								2							4						3				296
UKR008								3																	228
ROM007																									180
EST001																									130
GBR016		2						2		1	1				1								1	4	111
LTU001																									33
IRL029								1																	23
GRC005																								3	23
PRT005																									20
AUT005																									19
ARM005																					11				11

[1]Total collection including cultivated species

Representation of wild and marginally cultivated species in *ex situ* collections

Table 13 shows the representation of wild and marginally cultivated species collection wise according to the results of the survey. PGRC, Canada holds the greatest number of accessions for most of these species. For some species, which occur very restricted or endemic to Morocco, INRA Morocco holds the dominating part of the world collection: *A.atlantica* 23 accessions (56%), *A.damascena* 11 accessions (39%), *A.agadiriana* 19 accessions (51%), *A.magna* 141 accessions (55%) and *A.murphyi* 73 accessions (85%). Important collections for *A.strigosa* are held in the Vavilov institute, in the USDA, in Poland and in Brazil. Poland holds most accessions of *A.macrostachya* and *A.insularis*.
Table 14 shows a similar representation within the European catalogue EURISCO. It shows, that the Hungarian collection (HUN003), which did not participate in the questionnaire, has also accessions of rare species: *A.brevis*: 4, *A.nuda* (*A.strigosa* subsp. *nudibrevis*): 8, *A.magna*: 2. It also reveals, that some of the accessions held from rare and difficult species are not included in EURISCO.

g) Development status of the cultivated material in the collections

Table 15 lists the development status of the accessions as reported by participants of the questionnaire. This descriptor is not recorded in all collections (e.g. not in the USDA collection or in the IPK).

Table 15 Number of accessions of different development status in the collections, which responded to the questionnaire

INSTITUTION		Landraces	Obsolete varieties	Advanced varieties	Breeding materials	Unknown	Total Cultivated
N.I. Vavilov Research Institute of Plant Industry	RUS001	**5614**	613	1800	1325	553	9905
Plant Genetic Resources Centre, National Genebank of Kenya	KEN101	**4188**					4188
CAAS Institute of Crop Germplasm Resources	CHN001	**1518**	702			1004	3224
CRF Banco de Germoplasma Vegetal	ESP004	**1281**		16			1297
Plant Gene Resources of Canada, Saskatoon Research Centre	CAN004	**1187**		3300	4886	2184	11557
APTA - Polo Regional Desenvolvimento Tecnologico dos Agronegocios		579	444	60	70	5	1158
Aegean Agricultural Research Institute, Department of Plant Genetic Resources	TUR001	374		9		109	492
Pakistan Agricultural Research Council, National Agricultural Research Centre, Institute of Agri-Biotechnology and Genetic Resources, Plant Genetic Resources Programme	PAK001	296				2	298
Institut National de la Recherche Agronomique (INRA), Station d'Amelioration des Plantes	FRA040	287		111	479		877
Suceava Genebank	ROM007	125		1	4		130
Plant Science Agricultural Research and Training Institute	MNG001	110	41	650	520	27	1348
National Plant Genetic Resources Centre Plant Breeding and Acclimatization Institute	POL003	110		886	848	83	1927
Institute for Plant Genetic Resources `K.Malkov`	BGR001	100	1500	13	300	100	2013
Ustymivka Experimental Station of Plant Production	UKR008	94		325	97	90	606
Banco Portugues de Germoplasma Vegetal	PRT001	82					82
Austrian Agency for Health and Food Safety Ltd., Business Area Agriculture / Seed Collection	AUT001	78		153	21	3	255
Instituto Nacional de Investigación Agropecuaria, Estación Experimental La Estanzuela	URY003	70	100	20	200	445	835
Nordic Gene Bank	SWE002	46		184	79	1	310
Agricultural Research Organization, Volcani Center, Israel Gene Bank for Agricultural Crops	ISR002	6		3	43		52
Scottish Agricultural Science Agency	GBR165	6	586	31			623
Istituto Sperimentale per la Cerealicoltura, Bergamo	ITA037	3	9	456	135	94	697
Lieberman Germplasm Bank	ISR003				300		300
Estacao de Melhoramento de Plantas	PRT004		41	102			143
Estación Experimental Santa Catalina	ECU077				540		540
Embrapa Recursos Genéticos e Biotecnologia	BRA003		345			164	509

Further it is often not very reliable, as the concepts of landraces, obsolete and advanced varieties are shifting. Additional confusion has been brought into many databases by inconsistent number coding. Nevertheless it is remarkable, that the N.I. Vavilov collection has the highest number of landraces (5614) and the Kenyan curator classifies the total collection as landraces. Further high numbers of landraces are in the Chinese (1518), Spanish (1281), Canadian (1187), in the Brazilian APTA collection (579), in the Turkish (374), Pakistani (296), French (287), Romanian (125), Mongolian (110), Polish (110), Bulgarian (100), Ukraine (94), Portuguese (82), Austrian (78) and Uruguayan (70) collections. The Spanish, Turkish, Pakistani, Romanian, and Portuguese collections are almost completely dedicated to landraces.

h) <u>Gaps perceived in the collections by respondents of the questionnaire</u>

Gaps are recognized in most collections, as shown in Table 16. Most frequently gaps in species coverage are mentioned, which reflects the situation listed in Tables 3, 13 and 14. But also the other gaps mentioned in the questionnaire, insufficient population (sample) representation per species and insufficient ecological representation of the species are frequently agreed. Additional gaps have also been mentioned within the questionnaire and the following consultations, e.g. the lack of available origin data by the Polish curator.

In respect to its role as a World Base Collection PGRC Canada perceives the very low representation of material from Central Asia, especially hull-less cultivars as a gap. Furthermore, the poor representation of *A.macrostachya*, *A.ventricosa*, *A.damascena*, *A.atlantica*, *A.agadiriana*, *A.murphyi*, *A.trichophylla*, *A.matritensis* and *A.insularis is seen as a short-coming.* Exchange with other countries should be continued and further collecting activities considered. Collecting missions have been made in Italy and Ukraine, recently. Priorities in filling gaps are botanical (species, morphological groups) and geographical completeness.

Table 16 Gaps perceived in the collections by the respondents of the questionnaire

INSTITUTION		Data about origin	Ecological representation	Population representation	Species coverage
AUS003	Agricultural Research Centre, Australian Winter Cereals Collection		x	x	x
AUT001	Austrian Agency for Health and Food Safety Ltd., Seed Collection		x	x	x
BGR001	Institute for Plant Genetic Resources `K.Malkov`				x
BRA003	Embrapa Recursos Genéticos e Biotecnologia				x
BRA015	National Wheat Research Center		x	x	x
CAN004	Plant Gene Resources of Canada, Saskatoon Research Centre		x		x
CHN001	Chinese Academy of Agricultural Sciences, Institute of Crop Germplasm Resources				x
ECU077	Instituto Nacional Autónomo de Investigaciones Agropecuarias, Departamento Nacional de Recursos Fitogenéticos y Biotecnología, Estación Experimental Santa Catalina		x		x
FRA040	Institut National de la Recherche Agronomique (INRA), Station d'Amelioration des Plantes		x	x	x
ISR003	Tel-Aviv University Institute Cereal Crop Development Lieberman Germplasm Bank		x	x	x
ITA037	Istituto Sperimentale per la Cerealicoltura, Bergamo			x	x
JOR006	National Centre for Agricultural Research and Technology Transfer		x	x	x
KEN101	Plant Genetic Resources Centre, National Genebank of Kenya				x
MAR071	Institute National de la Recherche Agronomique, Breeding Unit, Forage Laboratory		x	x	x
MNG001	Plant Science Agricultural Research and Training Institute		x	x	x
NLD037	Centre For Genetic Resources, The Netherlands (CPRO-DLO)		x	x	x
POL003	National Plant Genetic Resources Centre Plant Breeding and Acclimatization Institute	x			
ROM007	Suceava Genebank		x		
SWE002	Nordic Gene Bank		x	x	
TUR001	Aegean Agricultural Research Institute, Department of Plant Genetic Resources		x		
UKR008	Ustymivka Experimental Station of Plant Production			x	x
URY003	Instituto Nacional de Investigación Agropecuaria, Estación Experimental La Estanzuela		x		x
USA029	USDA-ARS, National Small Grains Germplasm Research Facility		x		x

Plans to fill gaps have been mentioned also in several other cases. Bulgaria, which has already a considerable collection of wild species, intends to further collect wild species. In Brazil different collections mentioned different targets. Embrapa stresses the need to increase the quantity and the genetic variability of the oat collection by making introductions of genetic material demanded by the Research Centres and breeders. The National Wheat Research Center wants to focus collecting activity primarily in the country and thereafter elsewhere. The Chinese and Mongolian collections see means to fill gaps in the introduction of accessions of additional species of oat from other countries. Also the Bergamo collection cooperates with collections abroad to acquire *Avena* species of different ploidy levels.
The Spanish collection of landraces is considered as completed. Characterisation is a primary need for the future. For some of the wild species studies on the distribution and abundance, *in situ* conservation projects and further collecting of the restricted species are still needed. Marked genetic differentiation has been found in all analyzed species. Thus a loss of populations implies a loss of genetic diversity.
INRA Morocco stresses the needs for a conservation strategy to safeguard the endangered species by *in situ* conservation. Further collecting trips should be undertaken for all species and especially those, which are reported to be under the threat of genetic erosion. Regeneration of the collection is a very urgent concern for this collection. Also insufficient characterisation is seen as an important gap.
Romania sees an important task in collecting missions in the isolated regions of the Romanian Carpathian Mountains. Also AARI sees a priority in collection missions, which are organized every year for the species not sufficiently available in the genebank and distributed at sites with different ecological conditions. Also both Ukrainian institutes intend to fill gaps by joined missions together with other genebanks or by sampling in the country of landraces maintained by farmers. No plans are mentioned by Australia, Austria, Ecuador, France and the Netherlands. In Australia a national review of plant genetic resources is expected to determine the future. Current accessions are basically in response to requests by breeders. Oat is of low priority in the other mentioned countries and breeding programs have been ceased. In Jordan the wild oats are widely spread but are considered as a weed and thus have never been collected for conservation.

i) <u>Conservation status</u>

1) Coverage of the collection by long term, medium term and short term storage facilities

Coverage of the collection by long term, medium term and short term storage facilities is shown in Table 17. Most institutions have a high coverage of their collection by long term facilities. In some cases it may be justified, that not all material (e.g. working breeding material) needs to be covered by long term facilities. In the Vavilov collection and in the Mongolian large parts of the collection are not in long term facilities. According to I.Loskutov sufficient long term facilities would be available. The material will enter the long term facilities within the next regeneration cycle. In case of the Mongolian collection a large number of the collection is considered by the curator to be duplicated in other collections. More information about the value of this collection would be necessary to decide, whether a build up of the long term collection is to be considered necessary.
Some collections, as the National Wheat Research Center (BRA015), the La Molina collection (PER002), the International Livestock Research Institute (ETH013), Ustymivka Experimental Station of Plant Production (UKR008), the Istituto Sperimentale per la Cerealicoltura, Bergamo (ITA037), the INRA collection (FRA040) and the Lieberman Germplasm Bank (ISR003) do not have long term storage facilities. It needs to be clarified, whether other institutions already keep duplicates of important accessions of these collections in long term conservation (e.g. in Brazil, Israel, France, Italy, Ukraine) or a build up of long term facilities will be necessary (e.g. in Peru or Ethiopia). The collections in Peru and Ethiopia also reported to have mostly duplicated accessions.

Table 17 Coverage of the collection by long term, medium term and short term storage facilities

Institution		Long Term	Medium Term	Short Term
CAN004	Agriculture and Agri-Food Canada, Plant Gene Resources of Canada, Saskatoon Research Centre	26820 (100%)	26820 (100%)	
USA029	USDA-ARS, National Small Grains Germplasm Research Facility	20742 (95%)	21834 (100%)	
DEU146	Institute for Plant Genetics and Crop Plant Research – Gene-bank	4758 (100%)		
AUS003	Agricultural Research Centre, Australian Winter Cereals Collection	4601 (100%)		
KEN101	Plant Genetic Resources Centre, National Genebank of Kenya	4196 (100%)		
CHN001	Chinese Academy of Agricultural Sciences, Institute of Crop Germplasm Resources	2930 (90%)	456 (14%)	651 (20%)
POL003	National Plant Genetic Resources Centre Plant Breeding and Acclimatization Institute	2095 (100%)		
BGR001	Institute for Plant Genetic Resources `K.Malkov`	1740 (100%)	1100 (31%)	1910 (110%)
RUS001	N.I. Vavilov Research Institute of Plant Industry	**1000 (8%)**	**12155 (100%)**	**12155 (100%)**
MAR071	INRA Morocco	690 (100%)		
TUR001	Aegean Agricultural Research Institute, Department of Plant Genetic Resources	683 (86%)	803 (100%)	
URY003	Instituto Nacional de Investigación Agropecuaria, Estación Experimental La Estanzuela	638 (75%)		200 (25%)
GBR165	Scottish Agricultural Science Agency	634 (100%)		
ECU077	Estación Experimental Santa Catalina	544 (100%)		
NLD037	Centre For Genetic Resources, The Netherlands	536 (100%)	536 (100%)	
BRA003	Embrapa Recursos Genéticos e Biotecnologia	512 (100%)		
SWE002	Nordic Gene Bank	321 (100%)		
AUT001	Austrian Agency for Health and Food Safety Ltd., Business Area Agriculture / Seed Collection	256 (100%)	256 (100%)	
ROM007	Suceava Genebank	168 (93%)	180 (100 %)	
MNG001	Plant Science Agricultural Research and Training Institute	**150 (11%)**		**1200 (89%)**
EST001	Jogeva Plant Breeding Institute	131 (100%)		
GBR004	Millennium Seed Bank Project, Seed Conservation Department, Royal Botanic Gardens, Kew, Wake Hurst Place	(100%)		
BRA015	National Wheat Research Center			337 (100%)
ISR003	Tel-Aviv University Institute Cereal Crop Development Lieberman Germplasm Bank		1800 (100%)	
FRA040	Institut National de la Recherche Agronomique (INRA), Station d'Amelioration des Plantes		888 (100%)	
ITA037	Istituto Sperimentale per la Cerealicoltura, Bergamo		714 (100%)	
UKR008	Ustymivka Experimental Station of Plant Production		200 (33%)	408 (67%)
ETH013	International Livestock Research Institute		121 (100%)	
PER002	Universidad Nacional Agraria La Molina		100 (100%)	

2) The nature of the storage facilities (short, medium, long-term etc.)

Conditions reported for long term storage facilities are listed in Table 18. Generally facilities for long term conservation of the responding collections are on a high technical standard. Most work under deep freezing of –10 to -20°C. Some have humidity controlled at a low level (5-15%); others have it at least checked. Frequently dried seeds are sealed in aluminum bags, which put aside the necessity to control humidity in the storage room. No indication was given regarding free space still available in the stores.

Table 18 Technical parameters of the long term store of the genebanks, which participated in the questionnaire

INSTITUTION		Temp. [°C]	Humidity [%]	Aggregate
POL003	National Plant Genetic Resources Centre Plant Breeding and Acclimatization Institute	0	**5-6**	
RUS001	N.I. Vavilov Research Institute of Plant Industry	-10		
ECU077	Instituto Nacional Autónomo de Investigaciones Agropecuarias, Departamento Nacional de Recursos Fitogenéticos y Biotecnología, Estación Experimental Santa Catalina	-15		
DEU146	Institute for Plant Genetics and Crop Plant Research - Genebank	-15	<10%	
EST001	Jogeva Plant Breeding Institute	-18		Deep freezers
MAR071	Institute National de la Recherche Agronomique, Breeding Unit, Forage Laboratory	-18		Deep freezers
TUR001	Aegean Agricultural Research Institute, Department of Plant Genetic Resources	-18	Not Controlled	
CAN004	Agriculture and Agri-Food Canada, Plant Gene Resources of Canada, Saskatoon Research Centre	-18	Not Controlled	
MNG001	Plant Science Agricultural Research and Training Institute	-18-20	60-80	
CHN001	Chinese Academy of Agricultural Sciences, Institute of Crop Germplasm Resources	-18	57	
AUS003	Agricultural Research Centre, Australian Winter Cereals Collection	-18	40	
BGR001	Institute for Plant Genetic Resources `K.Malkov`	-18	**6**	
SWE002	Nordic Gene Bank	-18	**5**	
BRA003	Embrapa Recursos Genéticos e Biotecnologia	-20		
AUT001	Austrian Agency for Health and Food Safety Ltd., Business Area Agriculture / Seed Collection	-20		
NLD037	Centre For Genetic Resources, The Netherlands (CPRO-DLO)	-20	Not Controlled	
ROM007	Suceava Genebank	-20	Not Controlled	
URY003	Instituto Nacional de Investigación Agropecuaria, Estación Experimental La Estanzuela	-20	Not Controlled	
GBR004	Millennium Seed Bank Project, Seed Conservation Department, Royal Botanic Gardens, Kew, Wakehurst Place	-20	40	Long-term seed store
KEN101	Plant Genetic Resources Centre, National Genebank of Kenya	-20	18-20%	
USA029	USDA-ARS, National Small Grains Germplasm Research Facility	-20	25	
GBR165	Scottish Agricultural Science Agency	-20	- 15	Main Collection

Technical parameters of medium term storage facilities are shown in Table 19. They are of outmost importance in those collections, which do not have sufficient long term facilities. These are printed in bold. Medium term facilities, which give a full coverage of the Vavilov collection, are of high technical standard, especially regarding the low humidity.

Table 20 shows technical parameters of the short term facilities. Only the National Wheat Research Center (BRA015), the Mongolian genebank (MNG001) and the Ustymivka Experimental Station of Plant Production (UKR008) have a high proportion of their collection only under short term conditions. The Mongolian genebank uses seeds dried to 12-13% moisture content in paper envelopes and aluminum bags in a room with 0-15°C and 40-50% RH as short term storage.

Table 19 Technical parameters of the medium term store of the genebanks, which participated in the questionnaire

INSTITUTION		Temp. [°C]	Humidity [%]	Aggregate
AUT001	Austrian Agency for Health and Food Safety Ltd., Business Area Agriculture / Seed Collection	+10 to +16	30	
CAN004	Agriculture and Agri-Food Canada, Plant Gene Resources of Canada, Saskatoon Research Centre	+4	10-20	
RUS001	**N.I. Vavilov Research Institute of Plant Industry**	**+4**	**7**	
ROM007	Suceava Genebank	+4	Not controlled	
NLD037	Centre For Genetic Resources, The Netherlands (CPRO-DLO)	+4	Not controlled	
ITA037	**Istituto Sperimentale per la Cerealicoltura, Bergamo**	**+5**	**<20**	
USA029	USDA-ARS, National Small Grains Germplasm Research Facility	+5	25	
ETH013	**International Livestock Research Institute**	**+8**	**35**	
CHN001	Chinese Academy of Agricultural Sciences, Institute of Crop Germplasm Resources	0		
TUR001	Aegean Agricultural Research Institute, Department of Plant Genetic Resources	0	Not controlled	
ISR003	**Tel-Aviv University Institute Cereal Crop Development Lieberman Germplasm Bank**	**10**	**30-40**	
FRA040	**Institut National de la Recherche Agronomique (INRA), Station d'Amelioration des Plantes**	**4**	**15**	**Cold chamber**
PER002	Universidad Nacional Agraria La Molina	4	60	Chamber
BGR001	Institute for Plant Genetic Resources `K.Malkov`	6	12	

Table 20 Technical parameters of the short term store of the genebanks, which participated in the questionnaire

INSTITUTION		Temp. [°C]	Humidity [%]	Aggregate
MNG001	**Plant Science Agricultural Research and Training Institute**	**+15-20**	**30-50**	
RUS001	N.I. Vavilov Research Institute of Plant Industry	+20		
DEU146	Institute for Plant Genetics and Crop Plant Research - Genebank	+20	50%	
KEN101	Plant Genetic Resources Centre, National Genebank of Kenya	+5	18-20%	
URY003	Instituto Nacional de Investigación Agropecuaria, Estación Experimental	+7	35	
AUS003	Agricultural Research Centre, Australian Winter Cereals Collection	15	15	
BRA015	**National Wheat Research Center**	**3-5**	**30-40**	
CHN001	Chinese Academy of Agricultural Sciences, Institute of Crop Germplasm	4		
TUR001	Aegean Agricultural Research Institute, Department of Plant Genetic Re-	4	Not con-	
BGR001	Institute for Plant Genetic Resources `K.Malkov`	6	12	

3) Implementation of the Base and Active Collection concept

Genebank standards suggest having a base collection, which is not used for serving user requests. The latter function is up to the active collection. The base collection should be maintained under long term storage conditions. Table 21 shows the implementation of this concept at the genebanks, who responded to the questionnaire.

Some genebanks have a working collection additionally separated from the active collection. Most genebanks have their base collection under long term storage conditions, though several not reported to have an additional active or working collection. Genebanks not possessing long term storage facilities and thus having their “base” collection under medium or short term conditions have already been mentioned

Table 21 Available storage facilities for Active and Base Collection

INSTITUTION		Base Collection	Active collection	Working Collection	(Safety?) Duplicate collection
RUS001	N.I. Vavilov Research Institute of Plant Industry	Long term	Medium term	Medium term	Short term
CHN001	Chinese Academy of Agricultural Sciences, Institute of Crop Germplasm Resources	Long term	Medium term	Short term	
TUR001	Aegean Agricultural Research Institute, Department of Plant Genetic Resources	Long term	Medium term	Short term	
BGR001	Institute for Plant Genetic Resources `K.Malkov`	Long term	Medium term	Working	
AUS003	Agricultural Research Centre, Australian Winter Cereals Collection	Long term	Short term	Short term	
POL003	National Plant Genetic Resources Centre Plant Breeding and Acclimatization Institute	Long term	Long term		
AUT001	Austrian Agency for Health and Food Safety Ltd., Business Area Agriculture / Seed Collection	Long term	Medium term		
NLD037	Centre For Genetic Resources, The Netherlands (CPRO-DLO)	Long term	Medium term		
CAN004	Agriculture and Agri-Food Canada, Plant Gene Resources of Canada, Saskatoon Research Centre	Long term	Medium term		
ROM007	Suceava Genebank	Long term	Medium term		
GBR165	Scottish Agricultural Science Agency	Long term			Long term
USA029	USDA-ARS, National Small Grains Germplasm Research Facility	Long term		Medium term	
MNG001	Plant Science Agricultural Research and Training Institute	Long term		Short term	
KEN101	Plant Genetic Resources Centre, National Genebank of Kenya	Long term		Short term	
DEU146	Institute for Plant Genetics and Crop Plant Research – Genebank	Long term	Short term		
URY003	Instituto Nacional de Investigación Agropecuaria, Estación Experimental La Estanzuela	Long term	Short term		
GBR004	Millennium Seed Bank Project, Seed Conservation Department, Royal Botanic Gardens, Kew, Wakehurst Place	Long term			
BRA003	Embrapa Recursos Genéticos e Biotecnologia	Long term			
ECU077	Instituto Nacional Autónomo de Investigaciones Agropecuarias, Departamento Nacional de Recursos Fitogenéticos y Biotecnología, Estación Experimental Santa Catalina	Long term			
EST001	Jogeva Plant Breeding Institute	Long term			
MAR071	INRA Morocco	Long term			
SWE002	Nordic Gene Bank	Long term			
UKR008	Ustymivka Experimental Station of Plant Production	Medium term	Short term	Short term	
FRA040	Institut National de la Recherche Agronomique (INRA), Station d'Amelioration des Plantes	Medium term			Medium term
ISR003	Tel-Aviv University Institute Cereal Crop Development Lieberman Germplasm Bank	Medium term			
ITA037	Istituto Sperimentale per la Cerealicoltura, Bergamo	Medium term			
PER002	Universidad Nacional Agraria La Molina	Medium term			
ETH013	International Livestock Research Institute		Medium term		
BRA015	National Wheat Research Center	Short term			

The implementation of the base / active collection concepts mainly reflects the availability of respective storage facility. An effective strategy would be to have the active collection as a representative part of the base collection. Thus the base collection should normally be larger than the active collection. In some cases this is realized (Table 22), in few cases the opposite is the case, probably reflecting a lack of base storage facilities (see above) or backlogs in filling base storage facility with rejuvenated seed.

Table 22 Proportion of the collection in Base, Active and Working Collection

INSTITUTION		Base	Active	Working
CAN004	Agriculture and Agri-Food Canada, Plant Gene Resources of Canada, Saskatoon Research Centre	26819 (100%)	26819 (100%)	
USA029	USDA-ARS, National Small Grains Germplasm Research Facility	20134 (95%)		21194 (100%)
DEU146	Institute for Plant Genetics and Crop Plant Research - Genebank	4759 (100%)		
AUS003	Agricultural Research Centre, Australian Winter Cereals Collection	4443 (100%)		
KEN101	Plant Genetic Resources Centre, National Genebank of Kenya	4196 (100%)		
CHN001	Chinese Academy of Agricultural Sciences, Institute of Crop Germplasm Resources	2932 (90%)	458 (14%)	651 (20%)
POL003	National Plant Genetic Resources Centre Plant Breeding and Acclimatization Institute	2277 (100%)		
ISR003	Tel-Aviv University Institute Cereal Crop Development Lieberman Germplasm Bank	1800 (100%)		
BGR001	Institute for Plant Genetic Resources `K.Malkov`	1740 (100%)	700 (40%)	1210 (70%)
RUS001	N.I. Vavilov Research Institute of Plant Industry	**1000 (8%)**	**12155 (100%)**	**12155 (100%)**
FRA040	Institut National de la Recherche Agronomique (INRA), Station d'Amelioration des Plantes	888 (100%)		
ITA037	Istituto Sperimentale per la Cerealicoltura, Bergamo	714 (100%)		
MAR071	INRA Morocco	690 (100%)		
TUR001	Aegean Agricultural Research Institute, Department of Plant Genetic Resources	**683 (86%)**	**803 (100%)**	
URY003	Instituto Nacional de Investigación Agropecuaria, Estación Experimental La Estanzuela	638 (75%)	200 (25%)	
GBR165	Scottish Agricultural Science Agency	632 (100%)		
ECU077	Estación Experimental Santa Catalina	544 (100%)		
NLD037	Centre For Genetic Resources, The Netherlands	536 (100%)	536 (100%)	
BRA003	Embrapa Recursos Genéticos e Biotecnologia	512 (100%)		
BRA015	National Wheat Research Center	337 (100%)		
SWE002	Nordic Gene Bank	310 (100%)		
AUT001	Austrian Agency for Health and Food Safety Ltd., Business Area Agriculture / Seed Collection	256 (100%)	256 (100%)	
UKR008	Ustymivka Experimental Station of Plant Production	200 (33%)	408 (67%)	
ROM007	Suceava Genebank	180 (59%)	168 (55%)	
MNG001	Plant Science Agricultural Research and Training Institute	**150 (11%)**		**1200 (89%)**
EST001	Jogeva Plant Breeding Institute	131 (100%)		
PER002	Universidad Nacional Agraria La Molina	100 (100%)		
GBR004	Millennium Seed Bank Project, Seed Conservation Department, Royal Botanic Gardens, Kew, Wake Hurst Place	(100%)		
ETH013	International Livestock Research Institute		121 (100%)	

4) Conservation management systems

Participants of the questionnaire were requested to indicate, whether they have established management systems and written protocols, and whether these protocols could be made available to the Trust, for the following procedures:
Acquisition (including collecting, introduction and exchange), viability monitoring (germination tests), regeneration, characterisation, storage and maintenance, documentation, health testing of germplasm, distribution, safety-duplication, phytosanitary certification, packaging, shipping (Table 23). Additional procedures have been mentioned by the respondents, where they have a management system: seed drying (by the Nordic Genebank (SWE002) and by ILRI (ETH013), information exchange (by UKR008) and inventory (by CAN004). In most cases written protocols for the basic management procedures are already in place or in preparation (IPK Genebank).

Herbarium specimens for comparing true to typeness of regenerated material are completely available at the Vavilov institute. A reference collection of herbarium specimens has been recently established at PGRC, Canada. During regeneration of the oat collection from 1999-2004 verification of the botanical determination has been done with support by B.Baum and I.Loskutov.

Table 23 Availability of management systems for some indicated genebank management procedures

	Acquisition	Characterisation	Distribution	Documentation	Health testing of germplasm	Packaging	Phytosanitary certi-fication	Regeneration	Safety-duplication	Shipping	Storage and main-tenance	Viability monitoring
AUS003	Y[1]/Y[2]	Y/Y	Y/Y	Y/Y	N	Y	Y	Y/Y	Y/Y	Y	Y/Y	Y/Y
AUT001	Y/Y	Y/Y	N	Y/Y	N	Y	Y	Y/Y	N	Y	Y/Y	Y/Y
BGR001	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y
BRA003	Y/Y	N	N	Y/Y	Y/Y	Y/Y	Y/Y	D	N	Y/Y	Y/Y	Y/Y
BRA015		Y	Y	Y		Y	Y	Y	Y	Y	Y	Y
CAN004	Y/Y	Y/Y	N	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	N	Y/Y
CHN001	N	Y/Y	N/N	Y/Y	N/N			N	N/N		Y/Y	Y/Y
DEU146						Y/Y	Y/Y			Y/Y		
ECU077	Y/Y	N	N	Y/Y	N			N	N		Y/Y	Y/Y
EST001	Y/N	Y/N	Y/N	Y/N		Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
ETH013	N	N	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	N	Y/Y	Y/Y	Y/Y
FRA040	Y/Y		Y/Y		N	Y/Y	Y/Y	Y/Y		Y/Y		Y/Y
GBR004	Y		Y	Y		Y	N	Y	Y	Y	Y	Y
GBR165		Y/N		Y/N	N			Y/N	Y/N		Y/N	Y/N
ITA037	N	Y/N	N	Y/N	N	Y	Y	Y/N	N	Y	N	N
JOR006	Y/Y	Y/Y	Y/Y	Y/Y			Y/Y		Y/Y	Y/Y	Y/Y	Y/Y
KEN101	Y/Y	Y/Y	Y/Y	Y/Y	N	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y
MAR071	Y/N	Y/N	Y/N	Y/N	Y/N	Y	Y	Y/N	Y/N	Y	Y/N	Y/N
MNG001	Y/Y	Y/Y	Y/Y	Y/Y	N/N	Y/Y	Y/Y	Y/Y	N/N		Y/Y	Y/Y
NLD037	Y/Y	N	Y/Y	Y/Y	N	Y/Y		Y/Y	Y/Y	Y/Y	Y/Y	Y/Y
POL003	Y/Y	Y/Y	Y/Y	Y/Y		Y	Y	Y/Y		Y	Y/Y	Y/Y
ROM007	Y/N	Y/N	Y/N	Y/N	Y/N	Y	Y	Y/N		Y	Y/N	Y/N
RUS001	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y
SWE002	Y/Y	N	Y/Y	N	N	Y	Y	Y/Y	Y/Y	Y	Y/Y	Y/Y
TUR001	Y/Y	Y/Y	Y/Y	Y/Y		Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y	Y/Y
UKR008	N	Y/Y	Y/Y	Y/Y	N	Y/Y	Y/Y	Y/Y	N	Y/Y	Y/Y	Y/Y
URY003						Y/Y	Y/Y			Y/Y	Y/Y	Y/Y
USA029	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N

[1] Written protocols have been established, [2] written protocols can be made available to the Trust

Some examples of descriptions for quality control measures have been given:

Collecting	
ESP004	At sampling 1 panicle (or 1 seed) per plant is sampled and stored separately
Viability monitoring	
AUS003	Provided by third party laboratory. Require minimum of 85% for long term storage.
AUT001	Tests after harvest – before storage, every 10 years
BGR001	According ISTA rules.
BRA003	Initial time of storage; every 10 years for accessions stored over 85% of viability; every five years for accessions stored below 85% of viability.
BRA015	Every other year or whenever the seed amount comes to a limit.
CAN004	Test after regeneration prior to long term storage; seeds in storage tested randomly from different regeneration years and cycles, if less than 85 % viability found regeneration group, rejuvenation is initiated.
CHN001	Use germinating cabinet with instant temperate control
ECU077	Random sample of 10% of the whole collection for germination tests.
EST001	Selectively in 5 years. Less than 70% - regeneration
ETH013	5 year monitoring following ISTA rules
FRA040	underway : whole collection has been regenerated recently
GBR165	Samples from the oldest years are tested for germination using a tetrazolium test annually
JOR006	we do this test every 7 years for each collection, using agarose gel
KEN101	Top of paper, Agar: Regeneration conducted for materials which have less than 85% germination capacity
MNG001	Viability more than >80%
NLD037	Cultivated material: 2 x 100 seeds, ISTA rules. Monitoring interval depending on initial germination: 10 - 30 years; Wild material: 2x50 seeds, adapted ISTA rules. Monitoring interval 10 - 30 years;
POL003	Viability control with frequency 10 years.
ROM007	ITSA methods
RUS001	Visible methods.
SWE002	0,2 % KNO3
TUR001	Initial germination is tested before storage and currently in intervals the germination % are monitored.
UKR008	After each 3-5 years is tested the germinating power. If it is lesser of the initial one by 25% or more, the seed are directed for regeneration.
URY003	ISTA standard test every 5 years.
USA029	Viability test every 5-years
Regeneration	
AUS003	Use bags over panicles where necessary. Cross morphological attributes each time regenerated.
AUT001	UV-test obligatory, checking former characterisation
BRA003	When seed viability is below at least 80%.
BRA015	Isolated fields Bagging the panicles
CAN004	Morphological and agronomic characterisation compared to historic notes.
ECU077	According to ISTA if number of seeds permit.
ESP004	One seed per plant is sown, each plant descendant seeds are kept separately
ETH013	Isolation distances of 100m, minimum plant number of 100 where possible
FRA040	Comparison with reference panicle from former generation; comparison with description from international data bases or with literature description.
GBR165	Space plant beds
ITA037	Regeneration of the accession in the field, every 5-6 years (head-rows) and collection of some morphological characters; the harvested material is controlled by comparing the storage protein pattern to the protein pattern of the stored material.
MAR071	Big financial problem to ensure regeneration
MNG001	At least one per 8-10 year
NLD037	Regeneration when germination < 80% or when has dropped 15%; Wild material: regeneration when germination < 60%.
POL003	If viability drops below 80% for crop species and below 65% for wild species and landraces.
ROM007	In the evaluation field there are regeneration and multiplication plots, for each sowed species. Oat collection is regenerated in the same plots where we make primary characterisation of the genetic material.
RUS001	Visible methods.
SWE002	Regeneration according to genetic origin and type.
TUR001	Each accession of the collection is regenerated after a certain viability and quantity
UKR008	Checking for typeness is carried out on each plant development phase by morphological traits, dates of heading, disease resistance.
URY003	Depending on the amount of seed and germination; frequency: when needed.
USA029	Based on inventory and viability

Health testing of germplasm	
BGR001	Blotter Test
BRA003	In the initial of storage time. During 10/5 years seeds germination monitoring tests
CAN004	Field inspection for seed transmitted diseases, e.g. smuts, and removal of infected plants; seed inspection by pathologists if diseases symptoms are detected.
ETH013	Virus testing
FRA040	Clermont-Ferrand climate is very healthy for cereals; if a disease would appear, we would apply a fungicide treatment.
MAR071	According to ISTA rules
POL003	Only visual estimation according to the ISTA rules.
ROM007	Field observation , using the FAO scores
RUS001	Visible methods.
UKR008	Is estimated in field on natural infection background.

Seed Drying	SWE002	Drying to 3-5 % moisture.
	ETH013	Seeds dried to 5% MC
Information exchange	UKR008	New gene pool accessions acquisition, information exchange, giving the accessions for use.
Inventory	CAN004	Inventory is regularly updated.

5) The regeneration status of the material

Some collections reported regeneration backlogs, as listed in Table 24. Naturally the very large genebanks have the largest regeneration backlogs. The Canadian genebank gave a figure for total accessions and another for regenerated accessions. The difference is shown in Table 24, which the Canadian curator explicitly specified as in urgent need of regeneration. During the last six years regeneration and morphological characterisation at PGRC could be completed for *A.sativa* s. lat. (11631 accessions), which is relatively easy to regenerate. From the other species 26% have been regenerated during the last seven years, leaving more than 12,500 accessions of the more difficult wild species for regeneration. At the same pace their regeneration would need another 21 years.

Table 24 Regeneration backlogs in collections as reported by collections, which responded to the questionnaire

	Total	Regeneration Backlog per Species
CAN004	10986	*A.sterilis* 8769, *A.barbata* 1219, *A.fatua* 429, *A.vaviloviana* 99, *A.eriantha* 92, *A.abyssinica* 88, *A.clauda* 67, *A.occidentalis* 51, *A.longiglumis* 34, *A.brevis* 28, *A.hirtula* 18, *A.maroccana* 17, *A.canariensis* 16, *A.sativa* 13, *A.lusitanica* 11, *A.hybrida* 11, *A.nuda* 9, *A.wiestii* 6, *A.hispanica* 4, *A.ventricosa* 2, *A.insularis* 1, *A.macrostachya* 1, *A.atlantica* 1
USA029	3200	*A.sterilis* 3000, *A.barbata* 200
KEN101	2715	*A.sativa* 2715 (landraces)
MNG001	810	*A.sativa* 800 (400 advanced varieties, 300 breeding materials, 100 landraces), *A.strigosa* 3, *A.sterilis* 3, *A.brevis* 2, *A.abyssinica* 2
MAR071	582	*A. barbata* 157, *A.sterilis* 129, *A.magna 70, A.sativa* 62, *A.murphyi* 36, *A.hirtula* 30, A.*atlantica* 23, A.*agadiriana* 19, A.*longiglumis* 18, *A.clauda* 15, A.damascena 11, *A.wiestii* 6, *A.ventricosa* 5, A.*fatua* 1
BRA003	509	*A.sativa* 508 (345 obsolete varieties, 163 other), *A.fatua* 1
ISR003	400	*A.sterilis* 300, *A.sativa* 100 (Breeding materials)
BGR001	300	*A.sativa* (300 Breeding materials)
URY003	270	*A.sativa* (50 Advanced varieties, 50 Obsolete varieties, 20 Breeding materials, 150 Unknown)
TUR001	192	*A.sterilis* 87, *A.sativa* 53 (15 Landraces, 1 Advanced variety, 37 Unknown), *A.fatua* 35, *A.barbata* 15, *A.ludoviciana* 2
ECU077	80	*A.sativa* (Breeding material)
ITA037	63	*A.sativa* 50 (30 Breeding materials, 20 Unknown), *A.strigosa* 2, *A.magna* 2, *A.murphyi* 2, *A.sterilis* 2, *A.insularis* 1, *A.clauda* 1, *A.canariensis* 1, *A.nuda* 1, *A.barbata* 1
ROM007	25	*A.sativa* (Landraces)
NLD037	1	*A.sterilis*

The Vavilov collection indicates only very few differences in total and available accessions, related to some wild species (*A.bruhnsiana*, *A.clauda*, *A.damascena*, *A.hirtula*, *A.pilosa*, *A.prostrata*, *A.ventricosa*, *A.wiestii*, *A.agadiriana*, *A.macrostachya*). Here, it is not clear, whether the reason is regeneration backlogs or to keep some of those accessions out of the active collection. Yet it includes some very rare species (*A.damascena, A.ventricosa, A.agadiriana*, *and A.macrostachya)* and therefore should be noted. In the USDA collection urgent regeneration needs are explicitly stated for parts of the *A.sterilis* and *A.barbata* collections.
More than half of the collections have explicitly urgent regeneration needs in the cases of the Embrapa Recursos Genéticos e Biotecnologia (BRA003), the Kenyan (KEN101) and Mongolian (MNG001) collections. Considerable regeneration backlogs have been also reported for the Lieberman Germplasm Collection (ISR003), the Turkish (TUR001) and Moroccan (MAR071) collections. In CRF Spain multiplication is needed for most of the samples. Regeneration backlogs in the Bergamo collection (ITA037) should be noted as they comprise very rare species as *A.magna*, *A.murphyi* and *A.insularis*. In other cases backlogs refer to breeding material which value is not clear.
The Nordic Genebank, the Australian Winter Cereals Collection and the Austrian genebank explicitly stated to have no backlogs.

6) Regeneration facilities and conditions

Facilities available for regeneration and ecological conditions are listed in Table 25. Most collections have medium to high fertility soil. Oats are normally grown under rain fed conditions.

Table 25 Facilities and ecological conditions for regeneration

	Facility Code	Vegetation	Soil Type	Fertility	Irrigation
AUS003	Calala Field	May - November	Loam	High	irrigated
AUT001	Linz Field	March - August	Sand	Low/Medium	No
CAN004	AAFC Field Saskatchewan	May - September	Dark chernosem, loamy/clay texture, pH 7-7.5	High	After dry summer irrigated in autumn to fill to soil capacity for next vegetation period
CHN001	Datong	May - August		Medium-high	Rain fed
CHN001	Hohhot	May - August		Medium-high	Rain fed
DEU146	Gatersleben Field	March - August		High	
ECU077	Cayambe Field	January		Medium	No
ECU077	EESC Field Quito	January		Medium	No
ECU077	Lasso Field	January		Medium	No
ETH013	Debre Zeit Field	June - October	Alfisol	High	Sprinkler if required only
ISR003	Bet Dagan Field	October - May	Clay	High	Rain fed if irrigation
ITA037	Bergamo Field	October - July	Clay soil	High	Rain fed
	Marchouch field	November - June	Clay loam	High	Rain fed
MNG001	Darkhan Field	May - September	Chestnut	Medium	Irrigated
MNG001	Khovd Field	May - September	Chestnut	Medium	Irrigated
NLD037	Wageningen Field	October/March - August	Sand	medium	Irrigated
POL003	Radzikow Field	April - August	Clayey	High	Rain fed
RUS001	Daghestan Field	April - October	Chernozem	Medium	Rain fed
RUS001	Ekaterinino Field	April - October	Chernozem (Webster type)	Medium	Rain fed
RUS001	Kuban Field	April - October	Chernozem	Medium	Rain fed
RUS001	Maikop Field	April - October	Chernozem	Medium	Rain fed
RUS001	Moscow Field	May - September	Podzol	Medium	Rain fed
RUS001	Puskin Field	May – September	Podzol	Medium	Rain fed
SWE002	Alnarp Field	April		High	Rain fed
TUR001	Menemen Field				
UKR008	L'viv Field	April - August	Podzol	Medium	Rain fed
UKR008	Ustymivka Field	April - August	Black soil	Medium	Rain fed
URY003	La Estanzuela Field	April - November	Clay	Medium	No
USA029	Aberdeen Field	April - August		Low	Irrigated

7) Status of safety duplication

The status of duplication by germplasm exchange has already been mentioned in part c. This part will focus on safety duplication, as bilateral agreements to keep accessions of each other in a save store as insurance against losses, which might happen to a genebank due to disasters and war.
Table 26 shows safety duplication arrangements reported in the questionnaire. It is obvious, that bilateral arrangements between different countries regarding safety duplication are not yet very popular. In most cases countries or even institutions look for possibilities of safety duplications at other national institutions or sites within the same institutions. Even mobile freezer units are taken into consideration. Probably in many cases, the provisions should be called a base collection separate from the active or working collection - as in the case of USDA National Seed Storage Laboratory and National Small Grains Germplasm Research Facility.

Table 26 Safety duplication arrangements as reported by the respondents of the questionnaire

Holder		SDS Maintainer		Accn.	Conditions	Policy
DEU146	Institute for Plant Genetics and Crop Plant Research	DEU271	External Branch North of the Genebank, IPK, Malchow	500	Long term	Black box
EST001	Jogeva Plant Breeding Institute	SWE002	Nordic Gene Bank	11	Long term	Black box
FRA051	Unite Experimentale du Magneraud Geves	FRA040	INRA Station d'Amelioration des Plantes		medium	black box
GBR165	Scottish Agricultural Science Agency	GBR165	Scottish Agricultural Science Agency	10	long term	Mobile freezer unit at farm buildings
LTU001	Lithuanian Institute of Agriculture	SWE002	Nordic Gene Bank	14	Long term	Black box
LVA012	Stende State Plant Breeding Station	SWE002	Nordic Gene Bank	6	Long term	Black box
NLD037	Centre For Genetic Resources, The Netherlands	GBR011	John Innes Centre, Norwich Research Park	532	Medium term	Black box
RUS001	N.I. Vavilov Research Institute of Plant Industry	DEU146	Institute for Plant Genetics and Crop Plant Research - Genebank			
SWE002	Nordic Gene Bank	NOR038	Safety Base Collection of NGB	310	+4	Own safety collection
USA029	USDA-ARS, National Small Grains Germplasm Research Facility	USA005	National Seed Storage Laboratory, USDA-ARS	20542	Long term	Fully integrated
AUT001	Austrian Agency for Health and Food Safety Ltd., Seed Collection	NLD037	Centre For Genetic Resources, The Netherlands (CPRO-DLO)	151	Long term	Black box
TUR001	Aegean Agricultural Research Institute		Central Research Institute for Field Crops	29	Long term	Black box
UKR007	Institute of Agriculture & Cattle-breeding of the Western Region	UKR008	Ustymivka Experimental Station of Plant Production	404	Medium term	Fully integrated in host collection
UKR008	Ustymivka Experimental Station of Plant Production	UKR007	Institute of Agriculture & Cattle-breeding of the Western Region	404	Short term	Fully integrated in host collection
URY003	Estación Experimental La Estanzuela	DEU146	Institute for Plant Genetics and Crop Plant Research - Genebank	198		
URY003	Estación Experimental La Estanzuela	USA005	National Seed Storage Laboratory, USDA-ARS	208		
AUS003	Australian Winter Cereals Collection	AUS001	CSIRO Division of Plant Industry, Institute of Plant Production and Processing	4443	Long term	Black box
USA005	National Seed Storage Laboratory, USDA-ARS	ECU077	Estación Experimental Santa Catalina	5	Long term	
BRA015	National Wheat Research Center	BRA003	Embrapa Recursos Genéticos e Biotecnologia			
	Tasmanian Seed Centre	ECU077	Estación Experimental Santa Catalina	3	Long term	

j) The nature and extent of the data held on the material (including the extent of passport, characterisation and evaluation data, the format/data protocols followed, its availability on the internet, etc.)

Table 27 shows general facts of the computerization of genebanks that responded to the questionnaire. Most have at least basic computerization frequently based on Microsoft Office products (MS Access, MS Excel). 50% (15 out of 30) have already data online available and reported their URL. CDs or printed catalogues are distributed only in very few cases. Some collections reported additional plans to complete their online accessibility during the next three years, e.g. Embrapa Recursos Genéticos e Biotecnologia (BRA003), the Lieberman Germplasm Bank (ISR003), the Mongolian genebank (MNG001) and the Vavilov institute (RUS001).

Table 27 Basic facts on computerization and information exchange at the genebanks, who responded to the questionnaire

	Database Product	Computerization Planned	Printed Catalogue	CD Distribution	Online	URL
AUS003	MS Access			Yes	Partly	
AUT001	MS Access				Yes	http://www.genbank.at
BGR001					Yes	http://eurisco.ecpgr.org/
BRA003		Within 3 years	No			http:www.cenargen.embrapa.br
*BRAAPTA			No	No	**No**	
CAN004	Oracle, Apache, Neterm				Yes	http://www.agr.gc.ca/pgrc-rpc
DEU146				Yes	Yes	http://gbis.ipk-gatersleen.de/gbis_i/
ECU077	**MS Excel**	**No plans**	**No**	**No**	**No**	
EST001	MS Excel, MS Access				Partly	http://tor.ngb.se/sesto/
ETH013	Visual Fox Pro				Yes	http://www.singer.cgiar.org
FRA040	MS Access			No	**No**	
GBR004	Sybase					
GBR165				No	**No**	
ISR002					Partly	http://igb.agri.gov.il
ISR003	Microsoft Excel	Within 3 years	No	No	**No**	
ITA037	MS Excel		No	No	**No**	
KEN101	MS Access		No	Yes	**No**	
	MS Excel, GRIS		No	No	No	
MNG001	Germplasm Management System provided by IPGRI	Within 3 years	Yes	No	**No**	
NLD037	Oracle				Yes	http://cgn.wur.nl/pgr
POL003	MS Access, PostgreSQL			Yes	Partly	http://www.ihar.edu.pl/gene_bank/cereal/cereale.php?table=cereale&type=query&lang=pl
PRT001					**No**	
PRT004			No	No	**No**	
PRT005			No	No	**No**	
ROM007	Visual Fox Pro				Yes	http://svgenebank.ro
RUS001	Oracle Paradox 9	Completion within 3 years			Yes	http://VIR.NW.RU
SWE002	Own developed SESTO				Yes	http://tor.ngb.se/sesto/index.php?scp=ngb&thm=matobs&lev=prolst
TUR001			No	No	**No**	
UKR008	MS Access 97		No	No	Yes	http://eurisco.ecpgr.org/
URY003	MS Access, DBGermo	Within 3 years	No	No	**No**	
USA029	Oracle and Perl				Yes	http://www.ars-grin.gov

Table 28 shows the computerization of different data domains in the collections, which have shown some amount of computerization in Table 28. It shows the availability of passport, characterisation and evaluation data and a rough percentage estimate of available data. It is probably not fully comparable because it is depending on what curators consider a full data set.

For example the Australian curator is obviously looking very critically at his data. As CD he could provide a full accession list in Access format. The low percentages probably reflect the fact of frequently missing e.g. taxonomic information. This makes clear, that it is difficult to have an amount of computerization estimated without clear standards, which the data provided should fulfil. Initiatives (e.g. within the ECP/GR information network) are working on such standards, e.g. the Multicrop Passport Descriptors.
In most cases passport data are computerized for the core of the collections. Some collections (USA029, CAN004, DEU146, SWE002) have also characterisation and evaluation data fully or partly (MNG001, UKR008) available. Few collections (ITA037, GBR165) mention only evaluation (and characterisation) data, but not passport data.

Table 28 Computerization of data in the collections, who responded to the questionnaire

	Wild related species	Landraces	Obsolete improved varieties	Advanced improved varieties	Breeding/research materials
AUS003	P, C (1%)	P, C (15%)	P, C (18%)	P, C (15%)	P, C (20%)
AUT001		P, C (100%)		P, C (100%)	P (100%)
BGR001	P; C; E	P; C; E	P; C; E	P; C; E	P; C; E
CAN004	P, C, E (100%)	P, C, E (100%)	P, C, E (100%)	P, C, E (100%)	P, C, E (100%)
DEU146	P, C, E (100%)	P, C, E (100%)	P, C, E (100%)	P, C, E (100%)	P, C (100%)
ECU077		P (Partly)			
EST001			P, C, E (5%)	P, E (100%); C (9%)	
ETH013		P (100%)			
FRA040	P (12%)	P (99%)		P (13%)	P (100%)
GBR004	P (100%)				
GBR165		E (50%)	E (70%)	C, E (100%)	
ISR002	Partly				
ISR003	Partly				
ITA037			E	E	E
KEN101	P (100%)	P (100%)			
MNG001	P (100%); C, E (80%)	P (100%); C, E (91%)	P (100%); C, E (98%)	P (100%); C, E (69%)	P (98%); C, E (58%)
NLD037	P (100%)	P (100%)	P (100%)	P (100%)	P (100%)
POL003	P (88%)	P (100%)		P (100%); C, E (44%)	P (100%); C, E (9%)
PRT001	Yes (100%)				
PRT004	Yes (100%)				
PRT005	Yes (100%)				
ROM007		P, C, E (100%)	P (100%)	P (100%)	
RUS001	P; C; E	P, C, E (Partly)	P, C, E (Partly)	P, C, E (Partly)	P, C, E (Partly)
SWE002	P, C, E (100%)	P, C, E (100%)	P, C, E (100%)	P, C, E (100%)	P, C, E (100%)
TUR001	P (100%)	P (100%)		P (100%)	
UKR008	P (88%)	P (41%); C, E (20%)		P (10%); C, E (3%)	P (31%); C, E (8%)
URY003	Planned	Planned	Planned	Planned	Planned
USA029	P, C, E (100%)	P, C, E (100%)	P, C, E (100%)	P, C, E (100%)	P, C, E (100%)

P= Passport data, C= Characterisation data, E= Evaluation data

k) Distribution status

For ‘major’ collections information is presented on the availability of the material in terms of:

1) Physical availability (sufficiency of seeds stocks, procedures in place for phytosanitary certification, packaging, shipping, etc.)

Table 29 shows the availability of the collections for distribution. Physical availability is high (80-100% of the accessions) in most of the collections.

Table 29 Availability (%, physical, influence by health problems, and by policy restrictions) of material of collections, who responded to the questionnaire

INSTITUTION		Availability				
		Physical	Health	National	Regional	Global
AUS003	Agricultural Research Centre, Australian Winter Cereals Collection	95	No	100	100	100
AUT001	Austrian Agency for Health and Food Safety Ltd, Seed Collection	90	No	100	100	100
BGR001	Institute for Plant Genetic Resources `K.Malkov`	80	No	100	100	80
BRA003	Embrapa Recursos Genéticos e Biotecnologia	20	No	20		
BRA015	National Wheat Research Center	100	No	100	100	100 by agree-ment
CAN004	Plant Gene Resources of Canada, Saskatoon Research Centre	58	No	100	100	100
DEU146	Institute for Plant Genetics and Crop Plant Research – Genebank	90	No	100	100	100
ECU077	Estación Experimental Santa Catalina	50	No			
EST001	Jogeva Plant Breeding Institute	11	No	100	11	11
ETH013	International Livestock Research Institute	100	No			100
FRA040	INRA Station d'Amelioration des Plantes	95	No	100		100
GBR004	Millennium Seed Bank Project, Kew		No			
GBR165	Scottish Agricultural Science Agency			2	2	2
ITA037	Istituto Sperimentale per la Cerealicoltura, Bergamo	25	No	60	60	60
KEN101	Plant Genetic Resources Centre, National Genebank of Kenya		Yes			
MAR071	INRA Morocco, Breeding Unit, Forage Labora-tory	10	No	20	0	0
MNG001	Plant Science Agricultural Research and Train-ing Institute	25	No	30	10	20
NLD037	Centre For Genetic Resources, The Nether-lands (CPRO-DLO)	99	No	100	100	100
POL003	National Plant Genetic Resources Centre Plant Breeding and Acclimatization Institute	97	No	97	97	97
ROM007	Suceava Genebank	69	No	100	69	69
RUS001	N.I. Vavilov Research Institute of Plant Industry	100	Partly	100	100	100
SWE002	Nordic Gene Bank	100	No	100	100	100
TUR001	Aegean Agricultural Research Institute, De-partment of Plant Genetic Resources	65	No			
UKR008	Ustymivka Experimental Station of Plant Pro-duction	90	No	85	78	70
URY003	Instituto Nacional de Investigación Agropec-uaria, Estación Experimental La Estanzuela	65	No	100	100	100
USA029	USDA-ARS, National Small Grains Germplasm Research Facility	86	No	89	86	86

Physical availability around 50-70% is reported by the Estación Experimental Santa Catalina (ECU077), by the Canadian genebank (CAN004), the Suceava Genebank (ROM007), the Aegean Agricultural Research Institute (TUR001) and the Instituto Nacional de Investigación Agropecuaria, Estación Experimental La Estanzuela (URY003). Very low physical availability (< 25%) is reported by Embrapa Recursos Genéticos e Biotecnologia (BRA003), Jogeva Plant Breeding Institute (EST001), the Istituto Sperimentale per la Cerealicoltura, Bergamo (ITA037), the Moroccan (MAR071) and the Mongolian genebank (MNG001). In most cases there are no large differences in availability on national, regional or global level. An exception is Estonia. Here it is not clear, how it is to interpret, that the national availability is higher than the physical availability. A similar situation with very low physical availability is seen in Morocco and Mongolia. Morocco reports zero availability beyond the national level.
Disease problems, which may restrict availability are reported by Kenya and partly by the Vavilov institute. Material from Embrapa Recursos Genéticos e Biotecnologia (BRA003) seems to be only nation-

ally available. The Estación Experimental Santa Catalina (ECU077), the Kenyan genebank (KEN101), the Aegean Agricultural Research Institute (TUR001) and the Millennium Seed Bank Project (GBR004) did not make specifications about levels of availability of their collections.

2) Accessibility: the necessary government policies (e.g. status in relation to the IT, any other special considerations – such as phytosanitary limitations to sending material abroad, etc.)

Most collections provide phytosanitary certification (see management procedures). Table 30 lists use of a Material Transfer Agreement and costs or restrictions for the user.
Access to material is regularly free and without cost. Only two genebanks, the National Genebank of Kenya (KEN101) and the Estación Experimental La Estanzuela (URY003) take fees for the shipment of accessions. Most genebanks use a Material Transfer Agreement. Curators from China and Peru did not provide any information about accessibility of their collections.

Table 30 Policies in place for access to the material as reported by the collections, which responded to the questionnaire

INSTITUTION		IT	MTA	Fees for		User Restrictions
				Accessions	Shipment	
AUS003	Agricultural Research Centre, Australian Winter Cereals Collection	Yes ?		Free	Free	Yes
AUT001	Austrian Agency for Health and Food Safety Ltd / Seed Collection	pending	Yes	Free		Yes
BGR001	Institute for Plant Genetic Resources `K.Malkov`	Yes	Yes	Free	Free	No
BRA003	Embrapa Recursos Genéticos e Biotecnologia	Yes	Yes	Free	Free	Yes
BRA015	National Wheat Research Center	Yes	Yes	Free	Free	Yes
CAN004	Agriculture and Agri-Food Canada, Plant Gene Resources of Canada	Yes	No	Free	Free	No
CHN001	Chinese Academy of Agricultural Sciences, Institute of Crop Germplasm Resources	No				
DEU146	Institute for Plant Genetics and Crop Plant Research - Genebank	Yes	Yes	Free	Free	No
ECU077	Estación Experimental Santa Catalina	Yes	Yes			No
EST001	Jogeva Plant Breeding Institute	Yes	No	Free	Free	No
ETH013	International Livestock Research Institute	Yes	Yes	Free	Free	No
FRA040	Institut National de la Recherche Agronomique (INRA), Station d'Amelioration des Plantes	Yes	Yes	Free	Free	No
GBR004	Millennium Seed Bank Project, Kew		Yes	Free	Free	
GBR165	Scottish Agricultural Science Agency	No		Free	Free	
ISR003	Lieberman Germplasm Bank	No	Yes			No
ITA037	Istituto Sperimentale per la Cerealicoltura, Bergamo	No	No	Free	Free	No
KEN101	National Genebank of Kenya	Yes	Yes	Free	Cost	No
MAR071	INRA Morocco	Yes	Yes	benefit sharing	Yes	Yes
MNG001	Plant Science Agricultural Research and Training Institute	Yes	Yes	Free		No
NLD037	Centre For Genetic Resources, The Netherlands	Yes	Yes	Free	Free	Yes
PER002	Universidad Nacional Agraria La Molina	No				
POL003	National Plant Genetic Resources Centre IHAR	Yes	No	Free	Free	No
ROM007	Suceava Genebank	Yes	Yes	Free	Free	No
RUS001	N.I. Vavilov Research Institute of Plant Industry	No	No	Free	Free	No
SWE002	Nordic Gene Bank	Yes	Yes	Free	Free	No
TUR001	Aegean Agricultural Research Institute	Yes	Yes	Free	Free	Yes
UKR008	Ustymivka Experimental Station of Plant Production	No	Yes	Free	Free	No
URY003	Estación Experimental La Estanzuela	Yes	Depends	Free	Cost	No
USA029	USDA-ARS, National Small Grains Germplasm Research Facility	Yes	No	Free	Free	No

Restrictions set up for users of the genebank material have been outlined as follows:

- Restrictions set up by intellectual property rights have been mentioned by the Australian Winter Cereals collection (AUS003).
- (Direct) commercial use is excluded by Embrapa Recursos Genéticos e Biotecnologia (BRA003) and the Millennium Seed Bank Project (GBR004).
- Some genebanks (ETH013, ECU077, ISR003, NLD037) mention the conditions of Material Transfer Agreements (MTA).
- INRA Morocco mentions bilateral agreements in respect to the international treaties. Additionally countries must not have political problems with the country of origin and should give strong support to help in conserving, regenerating and breeding the genetic material.
- The Mongolian genebank (MNG001) puts forward equal mutual exchange of accessions and that the material has to be free from diseases.
- Turkey (TUR001) mentions national regulations (Regulation of The International Plant Genetic Resources Institute of Turkey): collections are available freely for research. But availability is mostly depending on the quantity and regeneration need.

3) Past experience with making materials available (numbers sent per year, to which countries, to which types of institution, etc.)

It is obvious from Table 31 that a national interest in national collections clearly dominates. High level of national request is held by the Russian, the USDA, the Canadian and the Australian genebanks. These also raise the highest international attention, especially the USDA collection. Its international attractiveness is very probably thanks to the excellent information system (http://www.ars-grin.gov), which is well known world wide and provides comprehensive information for most relevant purposes.

Table 31 Statistics on distribution by some genebanks, who participated in the questionnaire

INSTITUTION		Past annual distribution of accessions,				Estimated tendency		
		Recorded	Global	National	Regional	Global	National	Regional
RUS001	N.I. Vavilov Research Institute of Plant Industry	Yes	**151**	**3162**	**176**	No change	Increasing	Increasing
USA029	USDA-ARS, National Small Grains Germplasm Research Facility	Yes	**778**	**1558**				
CAN004	Plant Gene Resources of Canada	Yes	109	**1356**	171			
AUS003	Australian Winter Cereals Collection	Yes	26	**724**				
DEU146	Institute for Plant Genetics and Crop Plant Research – Genebank	No	30	100				
MNG001	Plant Science Agricultural Research and Training Institute	Yes	20	60	28	Increasing	Increasing	Increasing
UKR008	Ustymivka Experimental Station of Plant Production	Yes	18	44	18	No change	Increasing	No change
URY003	Estación Experimental La Estanzuela	Yes	0	50	0			
POL003	National Plant Genetic Resources Centre	Yes	11	33				
NLD037	Centre For Genetic Resources, The Netherlands	Yes	3	27				
AUT001	Austrian Agency for Health and Food Safety Ltd., Seed Collection	Yes	3	5	2	No change	No change	No change
MAR071	INRA Morocco, Breeding Unit, Forage Laboratory	Yes	0	0	0			
ECU077	Estación Experimental Santa Catalina	Yes	0	0	0			
EST001	Jogeva Plant Breeding Institute	Yes	15					
SWE002	Nordic Gene Bank	Yes	75		75	Constant		Constant
TUR001	Aegean Agricultural Research Institute	Yes		50			Increasing	
BRA015	National Wheat Research Center	Yes						
ETH013	International Livestock Research Institute	Yes	30					

Requests to most other genebanks have been below 100 *Avena* accessions per year. An increasing use of *Avena* genetic resources during the next five years is estimated by the Vavilov institute, the Mongolian genebank, the Ukrainian genebank, exclusively at the national level and the Turkish genebank at the national level.
Also an exemplification of the users requesting the collections (Table 32) shows a clear dominance of domestic users for most collections. An interesting exception is the Bergamo collection (ITA037). The Austrian collection, the IPK collection and the Nordic genebanks are requested by domestic and foreign user at equal parts. It is mostly academic research and public breeding, which requests genebank accessions. Considerable interest by private breeders is reported only for Sweden, Germany and Bulgaria. In France the main interest in oat genebank accessions comes from farmers.

Table 32 Requests (%) by different types of users

INSTITUTION		Domestic users	Foreign users		Academic	Genebanks	Farmers	NGOs	private breeders	public breeders
AUS003	Australian Winter Cereals Collection	96	4		5	3	1		3	88
AUT001	Austrian Agency for Health and Food Safety, Seed Collection	50	50		100					
BGR001	Institute for Plant Genetic Resources `K.Malkov`	10	2			2			10	
CAN004	Plant Gene Resources of Canada	90	10		6	50	2	2	0	40
DEU146	Institute for Plant Genetics and Crop Plant Research - Genebank	50	50		70	10			20	
EST001	Jogeva Plant Breeding Institute				50	50				
ETH013	International Livestock Research Institute		100		100					
FRA040	INRA Station d'Amelioration des Plantes	76	24		29	5	43		5	
ITA037	Istituto Sperimentale per la Cerealicoltura, Bergamo	10	90		90					10
MNG001	Plant Science Agricultural Research and Training Institute	80	20							
POL003	National Plant Genetic Resources Centre IHAR	75	25		80	3	5	1	3	7
SWE002	Nordic Gene Bank	50	50		50		10	10	20	10
TUR001	Aegean Agricultural Research Institute	88	12		32					68
UKR008	Ustymivka Experimental Station of Plant Production	67	33		11	11				78
URY003	Estación Experimental La Estanzuela									100
USA029	USDA-ARS, National Small Grains Germplasm Research Facility				50	5				25

l) <u>Networks (</u>Provide information on any networking or other international programs or arrangements for promoting partnerships and collaboration with respect to the genetic resources in question)

Networks with relevance for *Avena* genetic resources which have been mentioned in the questionnaire are listed in Table 33.
Collections participate in national, regional and global networks. National networks in many cases organize the national plans and responsibilities on genetic resources and often have to coordinate a multitude of institutions working in the sector. Important regional networks are the ECP/GR on the European level and related activities as EURISCO and the Central Crop Database. Information networking in the Nordic countries is affiliated with SESTO, a genebank management tool developed by the Nordic Gene Bank. In South America some networking has been mentioned around the software product DBGermo. Global networks cover breeding interests, as the Quaker nursery and a Uniform Oat Winter Hardiness Nursery, the FAO World Information and Early Warning System (WIEWS) and several international information projects as the Global Biodiversity Information Facility (GBIF) and the Pedigree of Oat Lines (POOL) database. Though GRIN is a national product of the USDA, it is of global relevance and is also used by Canada, thus considered as an international network. A large part of networking focuses on information and documentation issues.

Table 33 Networks for *Avena* genetic resources, as reported by collections in the questionnaire

Network	Level	Type	Objectives	URL	Informant
Quaker Nursery	Global	Breeding	Germplasm exchange/disease resistance		URY003
Uniform Oat Winter Hardiness Nursery	Global	Breeding	Cooperation with the aim of breeding winter hardy varieties of oat, selection under differential environmental conditions		POL003
WIEWS	Global	General		http://apps3.fao.org/wiews/wiews.jsp	
GBIF	Global	Information			
GRIN	Global	Information			
POOL	Global	Information	database of oat (*Avena* sativa) varieties and their pedigrees	http://*Avena*.agr.gc.ca/OGIS/about_e.php	CAN004
SINGER	Global	Information			
French Cereal Network	National	Conservation	Coordination of oats inventory and conservation		FRA040
Cerealie network	National	General	Knowing each other, finding funding for research		SWE002
PGRDEU	National	General			
System of Plant Genetic Resources of Ukraine	National	General	Maintain, research of PGR and providing with them of science, breeding, training and other programs		UKR008
ECP/GR	Regional	General	Contribution of IPK's *Avena* data to the *Avena* Database		DEU146
DBGermo	Regional	Information			
EADB	Regional	Information	Collect passport and evaluation information of oat accessions		RUS001
EPGRIS	Regional	Information	Searchable on line catalogue for European PGR		ROM007
EURISCO	Regional	Information			
IAC-SIGA	Regional	Information			
SESTO	Regional	Information			EST001

Table 34 Participation to the networks, as reported by respondents of the questionnaire and partly supplemented with additional information

Network	Participants*
Cerealie network	**SWE002**
DBGermo	**URY003**
EADB	**DEU146, PRT001, RUS001**, AUT001, (BEL001?), BGR001, CZE047, ESP004, EST001, FRA040, GBR005, GBR016, GRC005, HUN003, LTU001, LVA010, NLD037, POL003, PRT004, SVK003, SWE002, TUR001, UKR007, UKR008, (YUG009?)
ECP/GR *Avena* WG	AUT001, DEU146, FRA040, NLD037, SWE002, TUR001, ...
EURISCO	**AUT001, DEU146, NLD037, POL003, PRT005, RUS001** ARM005, AUT005, AZE006, BGR001, CHE063, CZE047, ESP004, EST001, GBR011, GBR016, GRC005, HUN003, IRL029, ITA060, LTU001, LVA010, NLD037, POL003, PRT005, ROM007, RUS001, SVK001, SWE002, UKR001, UKR007, UKR008
French Cereal Network	**FRA040**
GBIF	**DEU146, POL003**
GRIN	**CAN004, USA029**
IAC-SIGA	***BRAAPTA**
PGRDEU	**DEU146**
Quaker Nursery	**URY003**
SINGER	**ETH013**
Uniform Oat Winter Hardiness Nursery	**POL003**
WIEWS	**NLD037**

* Participants who mentioned their participation in the questionnaires are printed in bold

m) Perceived situation of current and estimated future support

Table 35 lists, how curators see the situation of their collections regarding inputs of support. Not sufficient base funding is stated by the Vavilov collection (RUS001), the EMBRAPA collection (BRA003), the Uruguay collection (URY003), the AWCC (AUS003), the collections in Ecuador (ECU077) and Mongolia (MNG001). The APTA collection and the Lieberman collection expect insufficient base funding in the future. Retention of trained staff is a problem in many collections related to low salaries in public service in many countries. Lacking interest of breeders has been also noted in many collections. Morocco additionally mentioned insufficient financial support by the government. The curators consider it moderately adequate currently but expect further cutbacks during the next years.

VI. Suggestions for strategies of a rational collection management

a) Criteria for identification and management of key collections

Criteria for the identification of important collections have been discussed in the Fargo and the St.Petersburg meetings. N.Tinker suggested, that definite criteria will have to be applied mainly to smaller collections, as the value of big collections like PGRC and USDA with more than 20,000 accessions, and the VIR collection with more the 10,000 accessions is out of doubt.
Collection diversity, uniqueness (on a species level), level of characterisation or description, level of documentation, availability of information and germplasm (public and SMTA exchange), costs for the use of the germplasm and risks for the collection have been identified at the Fargo meeting.
A clarification of terminology in the development of criteria was demanded in the St. Petersburg meeting. The terms of model collections, key collections or reference collections are frequently used, but do not yet apply in the current stage of the crop strategies. Uniqueness was outlined as an important criterion, but again the term would need to be clarified. Basically it would mean ‘not duplicated’. Finding out duplication would require huge database work on an accessions level. Still this would be based solely on data, not taking into account the real accessions, which may have been corrupted during their maintenance history. I.Loskutov stated that all wild material, all landraces and old materials referenced before 1945 are unique simply because of their lacking homogeneity and distinctiveness. Very old cultivars have been maintained over long time by different breeders and thus are different, even if they are named similar.
Further criteria were suggested: a broad representation of genetic diversity, a global or national representation of the collection, the localization in a centre of diversity, the availability of accessions to interested users, conservation standards, sustainable funding and the availability of data and characterisation information.
There was some discussion on biological status as a criterion. It was suggested that priority should be given to wild relatives and landraces. H.Bockelman explained at the Fargo meeting that landraces, especially from centres of diversity, are not replaceable. In the USDA collection he has made the experience that problems with landraces are less than assumed and they are fairly homogeneous. In St. Petersburg there was some dispute about the importance of wild relatives. Z.Zhang remarked that landraces should receive priority. Wild species can stay in the nature and are available there, as long as they are not threatened. B.Laliberte responded that the main function of collections regarding wild species is to make defined material accessible. There is no easy way to access wild material needed for certain traits in the nature. Because of different taxonomic systems used in different collections, G.Ladizinsky explained, that a reference to species number, e.g. the number of wild species can be very misleading. From the view of breeding use of the secondary and tertiary gene pools is very difficult. Inclusion of wild material requires time consuming back-crossing programs. Breeders and also the public sectors are increasingly unable to afford these pre-breeding efforts. Useful variation is primarily sought in marketable varieties and at most in the primary gene pool of the hexaploid species. This is in agreement with the priorities, which have been used by PGRC in regeneration of the oat collection: 1. *A.sativa* - 2. hexaploid taxa (mostly *A. sterilis*) - 3. *Avena* species which are unique to the collection due to past collecting activities - 4. The remaining accessions.

Table 35 Perceived situation of current and future support

	Base Funding		**Trained Staff**		**Donor Support**		**Diversity**		**Descriptive Data Access**		**Breeder Acceptance**	
	current	Tendency	current	Tendency	current	tendency	current	tendency	current	tendency	current	tendency
BGR001	High	High	Good	Good	Not sufficient	High	High	High	Not sufficient	High	Adequate	High
CAN004	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	High	High	High	High	Adequate	Adequate
DEU146	High	High	High	Adequate	Not sufficient	Not sufficient	Adequate	Adequate	Adequate	Adequate	Not sufficient	Not sufficient
NLD037	High	Adequate	High	Adequate	Adequate	Adequate	Adequate	Adequate	High	High	Not sufficient	Not sufficient
POL003	High	High	High	High	Adequate	Adequate	High	High	Adequate	High	Adequate	Adequate
RUS001	Not sufficient	-	Not sufficient	-	Not sufficient	-	Adequate	High	High	High	Adequate	High
SWE002	High	High	High	High	High	High	High	High	Not sufficient	-	Adequate	-
USA029	High	High	High	High	High	High	Adequate	Adequate	High	High	Adequate	Adequate
AUT001	Adequate		Adequate		Not sufficient				Adequate		Not sufficient	
BRAAPTA	Adequate	Not sufficient	Not sufficient	Not sufficient	High	High	Not sufficient	Not applicable	Not applicable	Not applicable	Adequate	Adequate
ROM007	Moderate	Adequate	Moderate	Adequate	Not sufficient	Adequate	Adequate	Adequate	High	High	Not sufficient	Adequate
TUR001	Adequate	Adequate	Adequate	Adequate	High	Adequate	High	High	High	Adequate	High	Adequate
UKR008	Adequate	Adequate	Not sufficient	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate
BRA003	Not sufficient	High	Not sufficient	Adequate	Not sufficient	High	Not sufficient	Adequate	Adequate	Adequate	Not sufficient	Adequate
URY003	Not sufficient	Adequate	Adequate	Adequate	Not sufficient	Adequate	Adequate	High	Not sufficient	Adequate	Adequate	
ISR003	Adequate	Not sufficient	Not sufficient	Not sufficient	Adequate		High		High		Not sufficient	
AUS003	Not sufficient	not sufficient	Not sufficient	Adequate	not sufficient	not sufficient	Not sufficient	not sufficient	Not sufficient	Adequate	Adequate	Adequate
ECU077	Not sufficient		Not sufficient		Not sufficient		Not sufficient				Not sufficient	
CHN001	Adequate	Adequate	Not sufficient	Adequate	Adequate	High	High	High	Adequate	High	Not sufficient	Adequate
MNG001	Not sufficient	Adequate	Not sufficient	Adequate	Not sufficient	Adequate	Adequate	High	Not sufficient	Adequate	Adequate	High
ETH013	Adequate	Adequate	Adequate	Adequate	Adequate/	Adequate	Not applicable	Not applicable	High	High	Not applicable	Not applicable
ITA037	Adequate		Not sufficient		Not sufficient		Adequate		Not sufficient		NA	
KEN101	Adequate	Adequate	Adequate	Adequate							Not sufficient	Not sufficient

In Fargo A.Diederichsen proposed also a ranking of: 1. Wild material from primary gene pool – 2. Wild material from secondary gene pool – 3. Adapted varieties – 4. Pre-breeding materials.

Breeders suggested most importance for pre-bred material, breeding lines and adapted (recently widely grown) varieties. Utilization of collections in the past has been put forward as an important criterion in the Fargo meeting. The breeders consider encouragement of use as a priority for conservation work. D.Stuthman stressed that interesting genes must be introgressed into a context more attractive to breeders. Germplasm exchange must be encouraged and he pointed to the fact that some countries are uncooperative in this respect. H.Bockelman responded that genebanks have never been in a position to deliver new breeding material. The main problem of having modern material distributed by genebanks is intellectual property rights. Collections generally have been mainly used in emergencies and it is mainly adaptability which determines their value. This point was taken up again in St. Petersburg and it was lastly agreed by most participants that wild species in collections are important, especially for cases of disastrous environmental changes or disease outbreaks, which might push to put more efforts into breeding again.

Regarding advanced and obsolete cultivars and breeding lines it was suggested to subsume them under the term 'developed material'. I.Loskutov gave some clarification on concepts of biological status and how to find it from information found in genetic resources databases: Landraces are characterised with a name "local", a name of specific traits, or a name of a breeder, who selected some material out of landraces. Advanced (or obsolete) cultivars have a registered cultivar name and information on pedigree or breeder, while breeding material has only a breeding number. B.Laliberte questioned whether these materials are considered necessary for a global conservation strategy. J. Koenig stressed that obsolete historic cultivars are important. A.Diederichsen suggested restricting the term 'developed' to 'obsolete and advanced cultivars', which have had a registration. Breeding lines should be kept separate.

G.Ladizinsky sees a major obstacle in genetic resources work in the lack of information useful to estimate the value of collections. An important criterion would be the strategy, which has been applied for collecting. He advised to use an ecological approach by looking in specific habitats for more effective collecting but also for estimating the value of a collection. A similar approach, the Focused Identification of Germplasm Strategy (FIGS), was presented by Michael Mackay. It is based on the hypotheses that new and novel alleles are more likely to be found in landraces and wild relatives, and that landraces and wild relatives of cultivated species reflect the selection pressures of the environment in which they evolved. FIGS is currently implemented for wheat in a collaborative project by VIR, ICARDA and AWCC. Based on geo-referencing collecting information, which is done at the participating genebanks, and by integration of environment layers with GIS technology, trait sets, e.g. for drought tolerance, mildew or salinity can be selected from the world collection. FIGS could be applied for any other crop. It is open source. Geographic origin and respective information on the ecological environment were accepted by all participants as key issues. A broader genetic representation could be achieved by looking at a broader geographic representation (e.g. the number of countries a collection is originating from). This would need additional information, also on an accessions level. To apply eco-geographical models geo-referencing of collecting sites and related environmental information will be necessary. Geo-referencing of collecting data was defined as a key issue for an information task force. Collection holders would need to verify and complete these data.

b) Summary of the available information on *Avena* collections

1) Global, regional and national important collections

Within the St. Petersburg meeting, based on the information available from the surveys and the knowledge of the participants, it was tried to categorize collections in those of global, national and regional importance (Table 1). The picture basically is characterised by a few very large collections with global coverage (PGRC Canada, USDA-ARS, VIR, IPK, AWCC, NGB Kenya) and many collections, some of which have a very clear focus on national or regional origin.

The Canadian collection is a global collection of high uniqueness. Because of the leading role Canadian collectors played in the exploration of *Avena* genetic resources during the 1960s and 1970s, the resulting broad coverage of the genus and the intense use of the collection in oat breeding it was as-

signed the status of a World Base Collection by IBPGR in 1976. This led to a big expansion by foreign material, especially from the USDA and the Nordic genebank. It has been integrated into the active collection during the 1980s to maintain a backup-collection representing the entire *Avena* gene pool. This gives the opportunity now to present scientific analysis of the entire *Avena* gene pool on a global basis as done by J.B.Fu and A.Diederichsen. On the other side it resulted in a duplication of PGRC and USDA collections of 68% (17561 accessions).
The USDA collection as well reflects huge activity in collecting, started approximately 100 years ago, and breeding in the United States. Already in 1948 several individual collections all over the country have been integrated to a national system. As there is no primary centre of diversity for small grain cereals in North America, there has been always a global focus and geographic coverage is similar to the Canadian collection. Shared with PGRC, Canada, it owns the largest *A.sterilis* collection in the world with some geographic bias towards Israel. Over 6000 *A.sterilis* accessions have been collected there during a program targeted to crown and stem rust resistance. Due to high breeding activity it contains almost 7000 accessions of national origin. Search for duplication is of very low priority in the USDA. Costs maintaining duplicate oat accessions are low and it is considered more important to spend efforts in gaps than in duplication. Nevertheless an activity has been started to combine GRIN with SINGER to look for duplication.
Also the VIR collection is a global and national collection. The global value mainly results from the very early collecting activities of Vavilov and co-workers all over the world. Local varieties have been collected mainly in the 1920s and 1930s, some still in the 1940s and 1950s. Later the uptake of bred materials dominated. The origin of the accessions is predominantly from Europe, with a great proportion (more than 3000 accessions) of national origin. Further accessions originate from North America and Asia, a small part from Africa, South America and Australia. The material in the collection is considered 80% unique. Genes, mainly for resistances have been identified in many accessions from the collection, some of them with multiple alleles. Characterisation and evaluation of the oat collection is done at eight stations from the most Northern to the most Southern parts of Russia. It is focussed to crown rust, stem rust, Helminthosporium blight and BYDV.
Similarly the IPK collection and the Australian Winter Cereals Collection have important global and national components. The AWCC is also a key national collection having about 500 accessions of national origin, probably landraces. These and another 500 accessions of collected material (wild species) can be considered unique. The National Genebank of Kenya has a very big collection of material foreign to the country. It is probably not unique, but the origin is not well known, identified only by country. In Kenya interest in oat as a food is increasing. Nevertheless little work is done in oat breeding and the collection is not much used in the country. Z.Muthamia, who represented the National Genebank of Kenya in the St. Petersburg meeting frankly raised the question whether the oat material should continue to be kept in Kenya or somewhere else. About 2000 accessions have already been sent to the USA. He thinks that most of the accessions are very old genotypes. Regeneration of the material is a big problem for the Genebank in Kenya. He estimated that about 50% of the material is still alive.
As national key collections the Bulgarian, Chinese, French, Mongolian, Moroccan, Spanish, and Turkish collections and the Israeli Lieberman germplasm bank were identified. The Spanish collection was not represented in the survey but was very well presented in the St.Petersburg meeting by P.Garcia. Most of the collection (95%) is of national origin, landraces collected in the 1940s. He reported 1643 accessions (298 accessions of wild material and 1150 accessions of landraces), 36 more than are listed in the downloadable passport list (see table 1). In Spain 333 populations of eight wild species have been collected. Of those 293 accessions from five species are available. From the very rare species *A.hirtula*, *A.canariensis* and *A.prostrata* no accessions are available, from *A.murphyi* only one accession. It needs to be clarified, whether this is due to regeneration backlogs or other reasons.
The Chinese collection is purely national and very unique especially regarding the high proportion of hull-less oat. The Lieberman germplasm bank has a focus on wild relatives (*A.sterilis*) from Israel, which is located in the centre of diversity of hexaploid oat. In this respect it is very unique. Most of the material was collected within a USDA project on crown rust. Also the Moroccan collection is an almost exclusive national collection with an important component of wild material, and located in the primary centre of diversity of the genus and the diploid and tetraploid species. About eighty percent of this collection is considered unique. The French collection has a clear national focus. It has a lot of French landraces and unique breeding material from the former INRA breeding programs. Eighty percent of the

Table 36 Structure and origin of key collections for which information available was considered sufficient

HOLDER	Country	Global collection	Key national	Regional	Centre of diversity	IT-PGRFA	Database	Total # accessions	# wild relatives[1]	# Landraces	# of species	# Developed material[2]	# Breeding materials	# Origin from national	# Introduced	Note on uniqueness
Winter Cereals Collection	Australia	yes	yes		No/S[3]	Yes	Yes	4601	549		7			422	667	500 Australian acc.
IPGR K.Malkov	Bulgaria	no	yes		No	Yes	Yes	2037	24	100	6	1513	300	321	1718	25% of Bulgarian
PGRC	Canada	yes	yes		No/S	Yes	Yes	26820	14935	1187	27	3300	4886	1784	17624	world base collection in 1980s
CAAS	China	no	yes		Yes?	**No**	Yes	3255	31	1518	4	702		2234	1023	Hull-less oat
RICP	Czech Rep.	no	no	yes	No	Yes	Yes	2066	0	100	7			11	1973	European
INRA-CLERMONT	France	no	yes		No/S	Yes	Yes	888	11	287	6	111	479	715	173	80%
IPK	Germany	yes	yes		No/S	Yes	Yes	4758	300		16			480	2315	
Lieberman Germplasm Bank	Israel	no	yes		Yes	**No**	Yes	1844	1544		8		300	1500		wild relatives
Kenya PGRC	Kenya	yes	no		No	Yes	Yes	4196	8	4196	2			11		not unique
PSARTI	Mongolia	no	yes		No	Yes	Yes	1358	10	110	5	691	520	46	1304	5% unique landraces
INRA Morocco	Morocco	no	yes		Yes	Yes	Yes	690	628		14			560	130	100% (20% safety duplicated in UK)
IHAR	Poland	no	yes	yes	No/S	Yes	Yes	2095	168	110	14	886	848	306	1316	European, 30% landraces
VIR	Russia	yes	yes		No/S	**No**	Yes	12112	2207	5595	25	2252	1310	3048	6563	80%
CRF	Spain	no	yes		yes	Yes	Yes	1643	298	1273	9			1599	44	77% landraces
AARI	Turkey	no	yes		Yes	Yes	Yes	803	311	374	5	9		803		only national material!
SASA	UK	no	yes		No/S	Yes	Yes	634	11	6	4	617		11		
USDA	USA	yes	yes		No/S	**No**	Yes	22242	10908		15			6992	14202	

[1] Wild and marginally cultivated species
[2] Obsolete and advanced varieties.
[3] High man-made (secondary) diversity resulting from high breeding activity in the past.

Table 37 Collection management at key collections for which information available was considered sufficient

HOLDER	Country	Base collection	Active collection	Long term	Medium term	Short term	Accessions safety duplicated	Safety duplication Policy	Safety Duplication Site
Winter Cereals Coll.	Australia	4601		4601			4601	Black box	AUS001
IPGR K Malkov	Bulgaria	1740	700	1740	1100	700			
PGRC	Canada	26820	26820	26820	26820				
CAAS	China	2930	456	2930	456	651			
RICP	Czech Rep.								
INRA-CLERMONT	France	888			888				
IPK	Germany	4758		4758			500	Black box	DEU271
Lieberman Germplasm Bank	Israel	1800			1800				
Kenya PGRC	Kenya	4196		4196					
PSARTI	Mongolia	150		150		1200			
INRA Morocco	Morocco								
IHAR	Poland	2277		2277					
VIR	Russia	1000	12155	1000	12155	12155			DEU146
CRF	Spain	1643	1597	1643	1643		108	Black box	NOR038
AARI	Turkey	683	803	683	803		29	Black box	
SASA	United Kingdom	632		632			10	Mobile freezer unit at farm buildings	GBR165
USDA	USA	20742		20742	21834		20542	Fully integrated	USA005

Table 38 Structure and origin of collections for which information available was considered insufficient, but which have responded to the detailed survey

HOLDER	Country	Global collection	Key national	Regional	Centre of diversity	IT-PGRFA	Database	Total # accessions	# wild relatives	# Landraces	# of species	# Obsolete varieties	# Advanced varieties	# Breeding materials	# Developed material	# Origin from national	# Introduced	Note on uniqueness
AGES	Austria				No/S	Yes	yes	256	1	78	2 (4?)		153	21		109	2	
CENARGEN	Brazil				No/S	Yes	?	512	3		4	345					512	
Embrapa	Brazil				No/S	Yes	?	337	254		14					22	309	100% introduced
Joegeva	Estonia				No	Yes	Yes	131			2					14	117	
INIA	Ecuador				No	Yes	Yes	544	4		2			540		428		national breeding material
ISC Bergamo	Italy	no	yes		No	Yes	Yes	710	13	3	10	9	456	135		49	665	most duplicated
CGN	Netherlands				No	Yes	Yes	536	18		9					78	172	
Suceava	Romania		yes		No	Yes	Yes	130		125	1		1	4		174	5	
NPGRC	Ukraine		yes		No	No	Yes	578	17	69	11		310	97		98	508	recently introduced from VIR and USDA
INIA	Uruguay	no	yes		No/S	Yes	Yes	853	18	70	2	100	20	200		70		most duplicated
NGB	Sweden	no	no	yes	No	Yes	yes	321	11	46	4		184	79				Nordic countries (98%)

Table 39 Collection management at collections for which information available was considered sufficient

HOLDER	Country	Base collection	Active collection	Long term	Medium term	# Short term	# Accessions safety duplicated	Safety duplication Policy	Safety Duplication Site
AGES	Austria	256	256	256	256		151	Black box	NLD037
CENARGEN	Brazil	512		512					
Embrapa	Brazil	337				337			BRA003
Joegeva	Estonia	131		131			11	Black box	SWE002
INIA	Ecuador	544		544					
ISC Bergamo	Italy	714			714				
CGN	Netherlands	536	536	536	536		532	Black box	GBR011
Suceava	Romania	180	168	168	180				
NPGRC	Ukraine	200	408		200	408	404	Fully integrated in host collection	UKR007
INIA	Uruguay	638	200	638		200	208		USA005
NGB	Sweden	310		310			310	Own safety collection	NOR038

collection is considered unique. The Turkish collection has exclusively national material. Resulting from the location of the country within the centre of diversity for hexaploid oats it is probably a very important collection. The Mongolian collection has 46 national landraces (5%). Despite the small size of this collection part, it is considered very important because of its probable uniqueness. The SASA collection has been considered a national collection, but it is primarily a reference collection for cultivar registration in the UK. Most of the collection is developed material.
In Europe there are additional collections with a regional (European) focus. G.Ladizinsky remarked that the centre of diversity of cultivated oat is Europe. But high diversity as a result of breeding activity can be also found in North America. This is indicated by S (secondary diversity) in Table 36. The Bulgarian collection, which has been considered as a national collection in the St. Petersburg meeting, with more than 300 accessions (25%) from Bulgaria, five percent of them landraces, could be put in this group. The Bulgarian genebank is the biggest in the Balkan region. Other collections with a European focus are the Czech collection (55% of European origin, 2% of unique Czech material) and the Polish collection, which has also an important national component: 30% of the collection consists of Polish landraces and unique own developed material.

2) Collections for which more information is needed

For some more collections (Table 38) the group felt not yet sure to indicate them as key collections and considered more information necessary. Some of them had responded very detailed in the survey, yet they were not represented in the meeting and may not have been so well known to the group.
The Nordic Genebank is the prototype of a regional collection covering the Scandinavian countries (98% of the collection). Most of the material is developed representing the long oat breeding tradition in the Nordic countries. Considering the important role Scandinavian countries have in oat production and oat breeding it should be considered important. Some of the other collections listed in the table have a national focus. The Austrian collection is a smaller collection with about 50% material of national origin, especially 78 landraces. It should be considered important regarding material of Alpine origin. Suceava genebank has almost exclusively accessions with Romanian origin. Landraces have been collected in the mountainous regions of the country very recently and are actively used in breeding programs mainly for cold resistance. There is additional national breeding material not listed in the official lists of accessions (see difference between national origin and total accessions). A larger proportion of introduced or unknown material is in the Dutch collection and in the Bergamo collection. In the Dutch collection *Avena* is of low priority, the Bergamo collection is a collection mainly for breeding purposes and as such interested in foreign material. I.Loskutov noted that the Ukrainian collection is mainly from repatriation programs for Ukrainian material from VIR and USDA. Most of the material is recently introduced.
Some more information is still needed from South America. Brazil and Uruguay represented South America in the Fargo meeting at a very early stage of the strategy development process. References in scientific literature point to considerable contributions of South America to diversity in the oat gene pool. F.Condon, at the Fargo meeting, confirmed, that *A.strigosa*, *A.sativa* and *A byzantina* are grown in Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay mainly as a fodder (hay) crop under high disease pressure. As a result this region develops into a secondary diversity centre evolving interesting traits of disease resistance. INIA Ecuador reported a high proportion of national breeding material in the collection. INIA Uruguay 65% introduced from other collections. F.Condon noted that the most interesting part are the local landraces, which show quite significant differences in cycle, growth habit and resistance mainly to aphids.

3) Other collections, which did not respond to the survey but nevertheless are considered to have important genetic diversity

Considerable collections not represented in the survey have been noticed as well (Table 39). Z.Zangh mentioned India, Japan and Korea. The AFFRC collection in Japan is well represented online at the URL (http://www.gene.affrc.go.jp/htbin/plant/SEARCH/common/e_search.cgi). It lists 1010 *Avena* accessions, 260 of them are of national origin. Z. Zhang also mentioned a collection in South Korea with 9619 oat accessions.

Table 39 Countries or collections, which have been considered by participants of the St. Petersburg meeting, which did not participate in the survey

HOLDER	Country	Centre of diversity	IT-PGRFA	Database	Total # accessions	# wild relatives	# Landraces	# of species	Obsolete varieties	Advanced varieties	Breeding materials	Origin from national	Introduced	Data source
?	Algeria	Yes	Yes											
	Cyprus	Yes	Yes											
IBCR	Ethiopia	Yes	Yes		24									IPGRI Directory
ICARDA	Global		Yes	yes										
GGB	Greece	Yes	Yes		23	3								EURISCO
NBPJR	India	No	Yes		1086									IPGRI Directory
IGFRI	India	No	Yes		1125									IPGRI Directory
	Iran	Yes	Yes											
	Japan	No	**No**		1529	0	32	1			94	260	750	online
PGL	Latvia	No	Yes	yes	5									EURISCO
LIA	Lithuania	No	Yes	yes	33									EURISCO
GCSAR	Syria	Yes	Yes		15									IPGRI Directory
INRAT	Tunisia	Yes	Yes		730	92								M.Chakroun
IGER	UK	No/S	Yes	yes	111	9								EURISCO
John Innes	UK	No/S	Yes	yes	2598	261								EURISCO
	North Korea	No	**No**											
	South Korea	No	**No**		9619									Z.Zhang

Algeria and Tunisia, besides Morocco are located in the primary centre of diversity. Good contacts could be established to Morocco and Tunisia. M.Chakroun from INRA Tunisia sent some information on the situation of oat genetic resources in the Maghreb and in Tunisia especially. The genebank of INRA Tunisia has 730 accessions, 92 of them wild species. No contacts could be established for Algeria. The Middle East, especially Turkey, Iran, Iraq, and Syria is a diversity centre for many cereal crops. It has been considered as a centre of diversity also for hexaploid oats (Murphy and Phillips, 1993). Loskutov (2005) mentions Iran, Georgia and Tatarstan as centre of diversity for *A.sativa*. Contacts could be established only to Turkey.

Ethiopia has endemic species *A.vaviloviana* (wild) and *A.abyssinica* (marginally cultivated). Contacts could be established only to the International Livestock Research Centre (ILRI). According to the Bioversity Directory the Institute of Biodiversity Conservation and Research has only 24 *Avena* accessions.

Central Asia has been discussed as centre of diversity as well, e.g. Georgia and Tatarstan for the hulled forms of *A.sativa* (Loskutov 2005). M.Mackay provided information that very little work on oat is done in this area; however, there is plenty of oats in the region, mostly wild oats. Dr. Bitore Djumakhanov in ICARDA's Tashkent was suggested as a contact point for more information.

In Latvia and Lithuania big differences can be found in different data sources. In EURISCO Latvia lists only five accessions, Lithuania 33. In the EADB and/or the Bioversity Germplasm Directory 615 accessions have been listed for Lithuania and 324 for Latvia. This may point to some rationalization of collections already ongoing or a big loss of material during the transition from Sowjet times. Similarly in IGER, UK the collection has been reduced from more than 300 to 111 accession, especially the large wild species collection from 172 to 9 accessions. Probably this collection is still represented as a backup in the John Innes Centre. The Greek Genebank reported only 23 oat accessions to EURISCO. No contacts could be established for Cyprus.

VII. Analysis of which collection holders are fully (or almost fully), partially or unable to readily make material available internationally.

Regeneration backlogs are the predominating reason for lack of availability. Very low physical availability (< 25%) is reported by Embrapa Recursos Genéticos e Biotecnologia (BRA003), Jogeva Plant

Breeding Institute (EST001), the Istituto Sperimentale per la Cerealicoltura, Bergamo (ITA037), the Moroccan (MAR071) and the Mongolian genebank (MNG001). A physical availability of 50-70% is reported by the Estación Experimental Santa Catalina (ECU077), the Canadian genebank (CAN004), the Suceava Genebank (ROM007), the Aegean Agricultural Research Institute (TUR001) and the Instituto Nacional de Investigación Agropecuaria, Estación Experimental La Estanzuela (URY003).

VIII. Synthesis of conservation and distribution

Identify those collections that fully (or almost fully), partially or fail to meet expected standards with respect to both conservation and distribution.

a) Lack of long-term storage for *Avena* collections

The following genebanks have only medium-term storage facilities for their *Avena* base collection:
Lieberman Germplasm Bank (ISR003, 1800 accessions), INRA Station d'Amelioration des Plantes, Clermont (FRA040, 888 accessions), Istituto Sperimentale per la Cerealicoltura, Bergamo (ITA037, 714 accessions), Ustymivka Experimental Station of Plant Production (UKR008, 200 accessions), International Livestock Research Institute (ETH013, 121 accessions), Universidad Nacional Agraria La Molina (PER002, 100 accessions). The Brazilian National Wheat Research Center (BRA015, 337 accessions) has only short-term storage facilities for their *Avena* collection.
More information is needed, whether these collections have backup collections somewhere else, e.g. a central national base collection.

Incomplete coverage of the *Avena* collection in the long-term collection is indicated for:
The N.I. Vavilov Research Institute of Plant Industry (RUS001): Only 1000 accessions (8%) are currently in the long-term collection. This situation will improve gradually during the regeneration cycle, as sufficient long-term facilities are available and all accessions will enter long-term storage after their next multiplication.
Plant Science Agricultural Research and Training Institute (MNG001): only 150 accessions (11%) are in long-term storage.

b) Regeneration backlogs

Regeneration backlogs are the most obvious problems faced by several genebanks (see section Vi5). Especially accessions of wild species are concerned, which are difficult to regenerate. The greatest part of the PGRC wild species collection (10986 accessions) still needs regeneration, including rare species like *A.magna*, *A.canariensis*, *A.longiglumis*, *A.brevis*, *A.hirtula*, and also a large part (8769 accessions) of *A.sterilis*. It is currently estimated, that a full regeneration of the wild species collection will take another 21 years and require respective working capacity. Also the USDA collection faces backlogs in the regeneration of *A.sterilis* and *A.barbata*.
Of the valuable collection of wild species in Morocco 582 accessions are in urgent need of regeneration, including 70 accessions of *A.magna*, 36 *A.murphyi*, 30 *A.hirtula*, 23 *A.atlantica*, 19 *A.agadiriana*, 18 *A.longiglumis* and 11 *A.damascena*. Backlogs in the regeneration of some wild species are also in the Bergamo collection. A large part of the Kenyan collection would need regeneration, yet the importance of this material is unclear. Also the Mongolian genebank has a regeneration backlog of more than 800 oat accessions, including 100 landraces and some accessions of wild or marginally cultivated species. Wild species and landraces are also concerned in the Lieberman collection and in the Turkish genebank.

c) Safety duplication

For the following collections no safety duplication arrangements are in place:
Institute for Plant Genetic Resources `K.Malkov` (BGR001), Embrapa Recursos Genéticos e Biotecnologia (BRA003), National Wheat Research Center (BRA015), Estación Experimental Santa Catalina

(ECU077), International Livestock Research Institute (ETH013), INRA, Station d'Amelioration des Plantes Clermont-Ferrand (FRA040), Lieberman Germplasm Bank (ISR003), Istituto Sperimentale per la Cerealicoltura, Bergamo (ITA037), National Genebank of Kenya (KEN101), INRA Morocco (MAR071), Plant Science Agricultural Research and Training Institute (MNG001), Universidad Nacional Agraria La Molina (PER002), National Plant Genetic Resources Centre Plant IHAR (POL003), Suceava Genebank (ROM007). In some other cases, safety duplication is only within the institution or country (see section Vk). This can help in cases of physical disaster, but not in cases of political or economical instability. The Trust offers co-funding of the establishment of safety duplication at Svalbard.

IX. Collaboration arrangements

a) <u>Networks already in place</u>

The AEGIS project ongoing within the framework of ECPGR was presented in St. Petersburg by J. Engels, the current AEGIS coordinator. The important role of oats in European genetic resources work is reflected by participation of the *Avena* Working Group and the European *Avena* Database as one of four crops in the current stage of this project. Approximately one third of world's genebanks and accessions are located in Europe and many of them participate in the European Cooperative Programme for Plant Genetic Resources (ECPGR) and respective Crop Working Groups already since 1980. Difficulties in proper PGR maintenance are seen mainly in the lack of long-term conservation facilities, insufficient safety-duplication and regeneration backlogs. Options for sharing conservation responsibilities have been discussed since 1998. Expected outputs of AEGIS are very similar to the Global Conservation Strategies: assess different approaches and propose models of cooperation, discuss pros and cons, propose an organizational structure, address legal and political issues, analyze the concept and propose Most Appropriate Accessions to be submitted to the system and draft guidelines on quality standards for long-term conservation. The *Avena* subgroup preferred a decentralized approach, sharing of responsibilities at an accession basis, taking country of origin for cultivated material or country of collector for wild material into primary consideration for defining the Most Appropriate Accessions. Subregional considerations are the starting point for deciding on primary conservation responsibility.
He also addressed the preceding concept of a Registry of Base Collections, which became dormant during the negotiations on the Treaty. He outlined major achievements, which should lead to success of similar initiatives now: The policy situation is now clearly defined by the Convention of Biological Diversity and the International Treaty. It is clear now that a formalized involvement of governments will be necessary. AEGIS will guarantee an active follow-up and management of the system and effective links between conservation and use. Modern IT technologies allow more decentralized approaches. A sustainable funding mechanism will be available with the Global Crop Diversity Trust.
Also an organizational concept has been proposed by the *Avena* subgroup based on the national genebanks as holders of the decentralized collection and a European Coordinating Lead Institution for *Avena* Genetic Resources coordinating the implementation of annual work plans, managing the central crop database, coordinating collecting activities, characterisation and evaluation e.g. as coordinator within EU programs and Svalbard as a primary safety duplication site. Quality standards will have to be in place for collecting and regeneration methodology, preparation for storage (especially drying regime), storage conditions, seed quality and viability monitoring and distribution practices. For wild species attention has to be given to specific environmental requirements for their regeneration, quarantine aspects in case of noxious weeds. Further steps should be the development of a model institutional contract, a quality management system, a survey of institutional capacities and service conditions and an assessment of economic implications. An legally-binding agreement at ministerial level is desired.
A.Diederichsen pointed to the fact that there was already a highly coordinated system under lead of the Vavilov institute in the in former Sowjet Union. Since then a strong tendency of decentralization followed. He recommended that experiences made by the Vavilov institute in managing the Eastern European Network should be exploited. Actually I.Loskutov is chair of the AEGIS *Avena* group. Z.Bulinska remarked that AEGIS should not compete with national interests, but should help to upgrade the national collections to AEGIS standards. J.Engels stressed the fundamental role of standards.

Close cooperation is between the two North American collections, also due to the common use of the GRIN database and software, though this cooperation is not formalized.
A breeding network, the Quaker Nurseries has been put forward repeatedly in the Fargo and St. Petersburg meetings as a model for international co-operation in genetic resources. It started in the 1960s as a grant by the American Agency for Development to develop germplasm for South America in cooperation between the universities of Wisconsin and Passo Fundo. After termination of the grant, Quaker Oats picked up funding for 30 years now. The main objective for Quaker oats is ensuring the availability of high quality milling oats for their mills in South America. Participation now goes far beyond the Americas and includes among others Australia and Tunisia. Taking advantage of participation from the Northern and Southern hemisphere, two generations per year are available. A strong relationship with CIMMYT exists. Participating breeders should develop and release well adapted varieties to their area out of material provided from university research. Disease resistance and milling quality are major target traits. A Code of Ethics has been established, which includes the right of crossing shared materials and a share of royalties (http://wheat.pw.usda.gov/ggpages/oatnewsletter/Code_of_Ethics.html).
Currently the program is focussed on new breeding material and there is no link between the Quaker nurseries and *ex situ* collections.

b) Information sharing mechanisms (global crop registries and databases)

As N.Tinker pointed out in St.Petersburg collections depend on funding, funding depends on value and value depends on information. C.Germeier listed some types of users. An international oat genetic resources information system will have to fulfil their requirements: Crop and breeding scientists need passport, characterisation, evaluation and molecular data on an accession level. Their interest is mainly crop specific but global, not in a single collection. They need the information available on the internet. They require a high level of accuracy and scientifically sound documentation, including methodological information, access to original data for (re-) evaluation of e.g. taxonomic, statistical or QTL analysis and a search facility over the whole world collection to select and download their working collections. They will normally work with lists of accessions and with variable sets of interesting descriptors. Breeders have quite similar requirements, but their priority is less on scientific complete documentation but more on the actuality, easy accessibility and comparability of data. They need data already harmonized or weighed in some way. Decision makers need collection and management summary data and their integration to a quality control system. In most cases they have a multicrop interest, but often will rely on crop specific expertise as in the crop strategies. They need the information available on the internet with high actuality. They require aggregated data, sorting and ranking procedures of high flexibility.
To avoid duplication of work, an information system should meet needs of all user types by providing adapted views to the underlying database. An accession-level database would best meet these requirements. Accession level data are routinely available in genebanks and they can be automatically summarized to a summary data level but not the reverse. In many respects, crop-specific data repositories are easier to handle and more comfortable for users. This does not exclude software development to be shared between crops on internet platforms like CropForge, which are already available.
Several elements of a global oat information system are already out: The Global Biodiversity Facility (GBIF) for distribution data, genebank information systems like GRIN and GRINCa and EURISCO for accession level passport data, GRIN, GRINCa and the EADB for accession-level characterisation and evaluation data, Pedigree of Oat Lines (POOL) for pedigree data, GrainGenes, OatGenes and Gelato for molecular data and the Bioversity Germplasm Directory for collection summary data. Options to proceed, as outlined by N.Tinker would be expanding existing databases, making interoperation available or build up a one-stop-shop. An example for the latter is the very successful sequence database Genbank, hosted at the US National Center for Biotechnology Information (NCBI). As main data types needed he listed taxonomy, morphology, pathology, agronomic performance, quality (end use characters), pedigree and genomic characterisation. In a new project Agriculture and Agri-Food Canada will start to integrate information on genotype, phenotype and pedigree. Open source micro array technology with DArT markers will be a powerful tool for molecular characterisation of oat genetic resources in the future.
The concept of virtual accessions used in POOL, which is very similar to the concept of virtual genotypes used in the EADB could be expanded to a global oat germplasm index cross referencing every

similar or duplicated accession to a global identifier and adding value to the index like pedigrees or other data not found in all collections. It also could provide a node to connect expanded data types from genotyping or phenotyping. J.Engels recommended contacting developers of ICIS, which already work on problems of non-orthogonal data as mentioned by N.Tinker.

It was agreed that the FIGS approach and geo-referencing of collecting information should be a first target for a global oat information network. A set of minimum descriptors would be required in a global index allowing the identification of entries. The problem of maintenance after a project phase should deserve special consideration and the initiative should provide a means for the upgrade of national information systems. VIR has started geo-referencing wheat data using a gazetteer within the FIGS project and the help of ICARDA and AWCC Australia. In a project supported by the ECPGR collecting site descriptions have been digitized and provided to the EADB for the VIR oat collection.

Considering some remarkable differences in information available from the European Avena Database, which attempts to keep elder information also during updates, compared to EURISCO (see Appendix II), often with more information available in the elder data of the EADB, it seems important, that a Central Database is curated by an interested crop working group. With an update organization merely replacing old data by new data, loss of accessions and information cannot be monitored. To make shortcomings in genebank management obvious such a monitoring will be important.

c) Pre-breeding

Already in the Fargo meeting there was a strong demand by breeders to enhance pre-breeding activities. R.Jonsson explained in the St.Petersburg meeting that breeders would need more pre-breeding by genebanks and universities, molecular tagging for marker assisted selection and still easier data retrieval from the information systems. To improve the use of germplasm he suggested, that utilization plans for genetic resources should be developed. They should be initiated by genebanks, funded by national governments or the EU and involve the scientific oat community and the oat industry. Z.Bulinska explained the co-operation of private breeders and genebanks in Poland: breeders fund specific projects in the genebank on different issues of their interest including pre-breeding. Also in Australia there is strong involvement of the private sector in genebank activities. M.Mackay recommended that genebanks should attend national breeding networks.

Further it is important to identify characters interesting for breeders. Currently resistance to *Fusarium* spp. and avoidance of mycotoxins production in oat is of primary interest. Most of the current varieties are susceptible. It was suggested to start pre-breeding activities with a monogenic, easy trait, which is nevertheless appealing. G.Ladizinsky would consider resistance to BYDV more appealing than rust resistance and a source of resistance is already available with the cultivar *Saja*. Regarding Fusarium, which seems to gain most interest, he raised the question whether it occurs on oats in the wild. M.Mackay confirmed that the environmental signature of the characteristic will have to be defined first. Nevertheless he suggested starting with Fusarium. Z.Zhang suggested, that different regions have different needs, and thus should look for different things.

d) Sharing of management standards and safety duplication

J.Engels suggested that all genebanks should write down procedures they follow and clarify terms and concepts. M. Mackay considers basic standards necessary for viability testing, regeneration and seed drying. Quality control should go along a guiding manual. Z.Bulinska mentioned that it is important to make things comparable between the genebanks. Documentation of standards is already available at VIR and CGN (English website based on their ISO certification).

B.Laliberte remarked that documentation of existing standards would be very laborious. Also it is questionable how much they are really implemented. She would prefer an agreement on minimum standards. It was agreed that the AEGIS group takes over the task to develop a standards manual. AEGIS standards should be developed by end of 2008.

Already available management standards should be shared. They could be sent to A.Diederichsen and he will make them available.

Regarding safety duplication B.Laliberte noted that the Global Conservation Trust supports transferring safety duplicates to Svalbard.

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Appendix I

Complete list of available quantitiative collection information, which could be identified during the study

INSTITUTION			OGCS Surveys	EURISCO	EADB	Bioversity Directory	Literature
CAN	CAN004	Plant Gene Resources of Canada, Saskatoon Research Centre	**27247**				
	~~CAN015~~	~~Agriculture and Agri-Food Canada, Cereal Research Centre~~	Have been merged into the PGRC collection in Saskatoon (A.Diederichsen pers. Comm.)			~~9500~~	
	~~CAN045~~	~~Agriculture Canada, Soil and Crops Research and Development Centre~~				~~7500~~	
	~~CAN017~~	~~Macdonald Campus of McGill University, Department of Plant Science~~				~~750~~	
	~~CAN005~~	~~Universite Laval, Departement de Phytologie~~				~~100~~	
USA	USA029	USDA-ARS, National Small Grains Germplasm Research Facility	**22242**			21093	
	USA005	National Seed Storage Laboratory, USDA-ARS				604 ?	
RUS	RUS001	N.I. Vavilov Research Institute of Plant Industry	**11711**	11857	13116	11814	
DEU	DEU146	Institute for Plant Genetics and Crop Plant Research - Genebank	**4758**	2903	2854	1851	
	DEU001	Federal Centre for Breeding Research on Cultivated Plants - Genebank			~~2094~~	1851	
AUS	AUS003	Agricultural Research Centre, Australian Winter Cereals Collection	**4601**			3674	
KEN	KEN101	Plant Genetic Resources Centre, National Genebank of Kenya	**4196**			3747	
	KEN051	National Dryland Farming Research Station, Kenya				9000 ?	
	KEN052	Kenya Agricultural Research Institute, National Agricultural Research Centre, Kitale				51 ?	
CHN	CHN001	Chinese Academy of Agricultural Sciences, Institute of Crop Germplasm Resources	**3255**			2955	
	CHN029	Chinese Academy of Agricultural Sciences, Grassland Research Institute				515 ?	
GBR	GBR011	Department of Applied Genetics, John Innes Centre, Norwich Research Park		**2598**	(2626)	2455	
	GBR005	Cambridge Laboratory, Institute of Plant Science Research (IPSR), Agriculture and Food Research Council			~~2626~~		
	GBR165	Scottish Agricultural Science Agency	**634**			489	
	GBR015	Dafs Cereal Cultivar Ref. Collect. Scottish Agricultural Science Ag.				410 ?	
	GBR016	Institute of Grassland and Environmental Research, Genetic Resources Unit		**111**	358	320	
	GBR040	National Institute of Agricultural Botany				80 ?	
	GBR004	Millennium Seed Bank Project, Seed Conservation Department, Royal Botanic Gardens, Kew, Wakehurst Place	**23**			13	
POL	POL003	National Plant Genetic Resources Centre Plant Breeding and Acclimatization Institute	**2095**	2274	1287	1866	
	POL001	Botanical Garden of the Polish Academy of Sciences				**79**	
BGR	BGR001	Institute for Plant Genetic Resources \`K.Malkov\`	**2037**	2308	356	1519	
CZE	CZE047	Agricultural Research Institute Kromeriz, Ltd.		**1984**	2000	1942	
ISR	ISR003	Tel-Aviv University Institute Cereal Crop Development Lieberman Germplasm Bank	**1844**			5500	
	ISR002	Agricultural Research Organisation, Volcani Center, Israel Gene Bank for Agricultural Crops	**169**			250	

INSTITUTION			OGCS Surveys	EURISCO	EADB	Bioversity Directory	Literature
CHL		Instituto de Investigaciones Agropecuarias, Centro Regional de Investigación Intihuasi, Banco Base					**1800**
	CHL004	Instituto de Investigaciones Agropecuarias, Centro Regional de Investigación Carillanca				**149**	230
MNG	MNG001	Plant Science Agricultural Research and Training Institute	**1358**				
ESP	ESP004	Instituto Nacional de Investigacion y Tecnologia Agraria y Alimentaria, Centro de Recursos Fitogenéticos, Banco de Germoplasma Vegetal		**1307**	2558	1246	
	ESP048	Instituto Canario de Investigaciones Agrarias				1	
HUN	HUN003	Institute for Agrobotany		**1228**	2183	2986	
	HUN020	Agricultural Research Institute Hungarian Academy of Sciences				**18**	
PER	PER002	Universidad Nacional Agraria La Molina				**1200**	1200
	PER070	Facultad de Agronomía, Universidad Nacional del Centro				**15**	27
UKR	UKR008	Ustymivka Experimental Station of Plant Production	**578**	228	50	675	
	UKR007	Institute of Agriculture & Cattle-breeding of the Western Region		**319**	326	210	
	UKR044	Institute of Agroecology and Biotechnology				1200 ?	
	UKR001	Yurjev Plant Production Institute, National Centre for Plant Genetic Resources of Ukraine		1			
BRA		APTA - Polo Regional Desenvolvimento Tecnologico dos Agronegocios	**1161**				
	BRA003	Embrapa Recursos Genéticos e Biotecnologia	**512**			512	500
	BRA006	Instituto Agronómico de Campinas				**405**	405
	BRA015	National Wheat Research Center	**337**			46	
	BRA102	Estação Experimental de Lages, EPAGRI				**26**	50
IND	IND027	Indian Grassland And Fodder Research Institute				**1125**	
	IND001	National Bureau of Plant Genetic Resources				**1086**	
FRA	FRA040	Institut National de la Recherche Agronomique (INRA), Station d'Amelioration des Plantes	**888**		820		
	FRA010	INRA Station d'Amelioration des Plantes			~~835~~	1504	
	FRA051	Unite Experimentale du Magneraud Geves				589 ?	
SVK	SVK001	Research Institute of Plant Production Piestany		**854**			
	SVK003	Breeding Research Station			93	503 ?	
URY	URY003	Instituto Nacional de Investigación Agropecuaria, Estación Experimental La Estanzuela	**853**			286	
TUR	TUR001	Aegean Agricultural Research Institute, Department of Plant Genetic Resources	**803**		643	810	
TUN	TUN001	National Institute for Agronomic Research (INRAT)	**730**				
ITA	ITA037	Istituto Sperimentale per la Cerealicoltura, Bergamo	**710**				
	ITA060	Istituto Sperimentale per la Cerealicoltura		**630**		210	
	ITA004	CNR - Instituto di Genetica Vegetale				**114**	
SWE	SWE002	Nordic Gene Bank	**321**	726	700	700	
	NOR038	Safety Base Collection Of NGB				**632**	
	SWE015	Dept. of Plant Breeding Research Uppsala Genet. Center, Uni. Agric				**200**	
MAR	MAR071	Institute National de la Recherche Agronomique, Breeding Unit, Forage Laboratory	**628**				
	MAR001	Institut Agronomique et Vétérinaire Hassan II				64	
UZB	UZB006	Uzbek Research Institute of Plant Industry (UzRIPI) the Avena collection comprises accessions of	**648**				

INSTITUTION			OGCS Surveys	EURISCO	EADB	Bioversity Directory	Literature
BEL	BEL001	Centre de Recherche Agronomique de l'Etat, Station d'Amélioration des Plantes			627 ?		
	BEL012	Center for Applied Biology				267 ?	
SYR	SYR002	International Centre for Agricultural Research in Dry Areas (ICARDA)				**548**	
	SYR003	Genetic Resources Department, General Commission for Scientific Agricultural Research				**15**	
ECU	ECU077	Instituto Nacional Autónomo de Investigaciones Agropecuarias, Departamento Nacional de Recursos Fitogenéticos y Biotecnología, Estación Experimental Santa Catalina	**544**			544	
	ECU023	Departamento Nacional de Recursos Fitogenéticos y Biotecnología (DENAREF)					540
NLD	NLD037	Centre For Genetic Resources, The Netherlands (cpro-dlo)	**536**	536	556	535	
	NLD027	Plant Breeding Station Cebeco-Zaden B.V.				**100**	
NZL	NZL027	New Zealand Institute for Crop and Food Research, Ltd.	**721**			**450**	
ROM	ROM012	Agricultural Research Station Lovrin-Timis				**440**	
	ROM007	Suceava Genebank	**130**	180		147	
	ROM024	University of Agricultural Sciences Cluj				**37**	
JPN	JPN003	National Institute of Agrobiological Sciences, Genetic Resources Management Section, NIAR, MAFF				**426**	
	JPN055	National Agricultural Research Center for Kyushu Okinawa Region KONARC				**235**	
ZAF	ZAF049	Small Grain Centre, Grain Crops Research Institute, Department Of Agriculture And Water Supply				**379**	
	ZAF001	Department of Agriculture, Division of Plant and Seed Control, Section Genetic Resources				**364**	
	ZAF058	Grassland Research Centre, Department of Agricultural Development				**47**	
FIN	FIN020	Boreal Plant Breeding Institute				**361**	
PAK	PAK001	Pakistan Agricultural Research Council, National Agricultural Research Centre, Institute of Agri-Biotechnology and Genetic Resources, Plant Genetic Resources Programme	**323**				
	PAK002	Institute of Agricultural Biotechnology and Genetic Resources				**113**	
	PAK011	New Seed Farm, Fodder Research Institute				**21**	
LVA	LVA010	University of Latvia, Institute of Biology, Plant Genetics Laboratory		5	324		
	LVA012	Stende State Plant Breeding Station				**305**	
	LVA018	Latvian Agriculture Academy				20	
AUT	AUT001	Austrian Agency for Health and Food Safety Ltd., Business Area Agriculture / Seed Collection	**256**	296	304	240	
	AUT012	Kaerntner Saatbaugenossenschaft GmbH				53	
	AUT034	Federal Office and Research Centre for Agriculture - Medicinal Coll.				83	
	AUT005	Genebank Tyrol / Tyrolean Government		19		13	
YUG	YUG001	Maize Research Institute Zemun Polje				**171**	
	YUG009	Small Grains Research Centre, Agricultural Research Institute `Serbia`			**168**		
ETH	ETH013	International Livestock Research Institute				**147**	
	ETH001	Plant Genetic Resources Centre				**24**	
NGA	NGA010	National Centre For Genetic Resources And Biotechnology				**146**	

INSTITUTION			OGCS Surveys	EURISCO	EADB	Bioversity Directory	Literature
PRT	PRT004	Estacao de Melhoramento de Plantas	**143**		41	100	
	PRT001	Banco Portugues de Germoplasma Vegetal	**82**			73	
	PRT005	Department of Genetic Resources and Breed-ing, Genebank	**8**	20			
EST	EST001	Jogeva Plant Breeding Insitute	**131**	130	135	130	
ALB	ALB007	Food and Agriculture Ministry, Forage Re-search Institute				**56**	
	ALB001	Agricultural University, Department of Agron-omy, Plant Breeding and Seed Production Section				**20**	
GRC	GRC005	Agricultural Research Centre of Makedonia and Thraki, Greek Genebank		**23**	21	42	
	GRC001	Cereal Institute, National Agricultural Research Foundation				41	
LTU	LTU001	Lithuanian Institute of Agriculture		33	615	32	
IRL	IRL029	Irish Genetic Resources Conservation Trust (IGRCT)		23			
ARM	ARM005	National Academy of Sciences of Armenia, Institute of Botany		11			
GEO	GEO004	Protection Society of Agrobiodiversity				11	
DNK	DNK044	Crop Science Institute KVL			10		
NOR	NOR022	Department of Horticulture, Agricultural Univer-sity of Norway			10		
ARG	ARG017	Instituto Nacional de Tecnología Agropecuaria, Instituto de Recursos Biológicos, Banco Base Nacional de Germoplasma				5	
CHE	CHE063	Pro Specie Rara		1			
AZE	AZE006	Forage crops, Meadows and Rangelands Research Institute, Ministry of Agriculture		1			

Some further very small collections listed in the Bioversity Directory of Germplasm collections (CHE091, COL029, SVK022 with one accession, CAN122 and CZE082 with two CHE097 and SVK035 with three, PRT006 with four, AUS201 and LBY001 with five, VNM002 with eight and MDG002 with eleven, NLD021 with 15 and ROM009 with 21 accessions have not been taken up into the database. AUT006 and AUT034 are duplicate addresses in the FAO address table.