Directorate General for Agriculture and Rural Development

Preparatory action on EU plant and animal genetic resources

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WORKSHOP REPORT

Better integration of *ex situ* and *in situ* approaches towards conservation and sustainable use of GR at national and EU level: from complementarity to synergy.

3 June 2015, Brussels

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The Workshop took place in the context of the study launched by DG AGRI of the European Commission called "*Preparatory action on EU plant and animal genetic resources*" which is being conducted by a Consortium of experts and consultants. It started in July 2014 for duration of 2 years.

A total of 7 different workshops are planned during the period June 2015 – March 2016. Each workshop is dedicated to specific topics/issues linked to a specific regional context and/or covering sectorial or methodological issues in the field of genetic resources. These workshops cover the four different domains under scrutiny: PGR, AnGR, FGR, and MiGR.

The outcomes of the workshops should provide recommendations concerning approaches and solutions applicable for the conservation and sustainable use of GR, reflecting the objectives and themes of the preparatory action.

More information on the objectives of the study can be found on the study website: http://www.geneticresources.eu.

The Workshop is the first of the series.

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1 Introduction

The first workshop on "*better integration of ex situ and in situ approaches towards conservation and sustainable use of GR at national and EU level: from complementarity to synergy"* was held by the study Consortium in Brussels on June 3, 2015. It was prepared by:

- **Riccardo Bocci** (Rete Semi Rurali, Italy);
- **Sipke Joost Hiemstra** (Centre for Genetic Resources, the Netherlands (CGN), Wageningen University and Research Centre); and
- **Daniel Traon** (Arcadia International E.E.I.G.).

The following additional experts highly participated in the success of the workshop in their capacity of moderators, rapporteurs or presenters:

- **Fulvio Ducci** (CRA-SEL Arezzo-IT)
- **Gustavo Gandini** (University of Milano-IT)
- **Theo van Hintum** (Centre for Genetic Resources, the Netherlands (CGN), Wageningen University and Research Centre)
- **Nigel Maxted** (University of Birmingham-UK)
- **Marjana Westergreen** (Slovenian Forestry Institute-SI)
- **Sebastian Winkel** (BLE-DE)

The focus of Workshop 1 was to explore options for better integration and more synergy between *in situ* and *ex situ* conservation approaches.

1.1 Background

Literally *ex situ* means "*out of place*". In the context of conservation of species, breeds or varieties, it means "*activities that take place outside of their natural habitat*" (Article 2 of the Convention on Biological Diversity (CBD)-1992). A variety of gene banks have been established and maintained for the purpose of *ex situ* conservation of genetic resources for food and agriculture. As defined by the CBD and the International Treaty on Plant Genetic Resources (ITPGRFA) (FAO, 2001), *in situ* conservation means "*the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated plant species, in the surroundings where they have developed their distinctive properties*".

Multiple publications have indicated that *ex situ* and *in situ/on-farm* approaches are/should be complementary to promote conservation and sustainable use of genetic resources. These complementary conservation strategies have advantages and disadvantages with respect to specific conservation objectives, and individual

strategies can include a wide range of activities to support the conservation and sustainable use of genetic resources. Of particular importance, there is a variety and large number of actors, contributing to or leading particular conservation strategies.

Coordination at national, regional and global level is needed to strengthen linkages between *ex situ* and *in situ* conservation efforts. In the 2nd State of the World on Plant Genetic Resources (PGRs) (FAO, 2010) key gaps and needs were identified, including the need for better coordination and collaboration between different stakeholders and actors, and strengthening the linkages between institutions primarily concerned with conservation and those concerned primarily with its use. The Global Plan of Action on Forest Genetic Resources (FAO, 2014) emphasised the long-term goal to maintain genetic diversity and the evolutionary processes of forest species, by better implementing and harmonising measures to conserve Forest Genetic Resources (FGRs), both *in situ* and *ex situ*, including through regional cooperation and networking. Similarly, the Global Plan of Action for Animal Genetic Resources (FAO, 2007) also indicated that activities related to *in situ* conservation, to *ex situ* conservation, and to the utilisation of animal genetic resources for food and agriculture, have been largely pursued without adequate linkages and coordination.

In situ and *ex situ* approaches both have strengths and weaknesses. Complementarity of *in situ* and *ex situ* strategies should be effective and efficient both at national and European level. The question is how better integration of *in situ* and *ex situ* approaches can contribute to a more effective and efficient European strategy for conservation and sustainable use of genetic resources[1].

1.2 General challenges for improved integration on conservation and use of GR

There is a variety of actors contributing to the conservation and sustainable use of plant, animal and forest genetic resources. On one hand, the involvement of many actors is dynamic; on the other hand better coordination could contribute to a more effective and efficient conservation strategy at national and European level.

The idea of promoting networking between actors (not only scientific ones) for a more efficient way of conserving and sustainably using genetic resources (GRs) is already pointed out by the new EU research programme Horizon 2020, and also by the FAO Commission on Genetic Resources for Food and Agriculture (CGRFA).

[1] FAO. 2015. *The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture*, edited by B.D. Scherf & D. Pilling. FAO Commission on Genetic Resources for Food and Agriculture Assessments. Rome (available at http://www.fao.org/3/a-i4787e/index.html).

Integration of *in situ* and *ex situ* management processes, and collaboration at all levels of conservation action is needed, including planning, implementation, monitoring and finally assessment to drive adaptive management processes (Schwartz, 2015). *Ex situ* conservation is i.e. used to support *in situ* conservation to the best effect possible and vice versa.

This integration has to be considered domain per domain as each of the three domains (PGRs, AnGRs and FGRs) are rather specific in terms of their features, objectives, scope, governance and actors. As regards the current situation, it seems that, when challenges exist in the three domains, issues may be different in nature and importance. The workshop aims at identifying these issues for the three domains and collectively. Biological, operational and institutional differences have been identified between the PGR and AnGR sectors (e.g. 1st FAO State of the World's AnGR). Conservation programmes are organised differently and the different roles of public and private actors also determine the characteristics of *in situ* and *ex situ* conservation strategies.

For PGR, formal and informal seed systems exist. Formal and farmers' seed systems differ in how they use and maintain plant genetic resources. The formal seed systems consist of chains of interlinked activities, starting from genetic resource management, scientific breeding research and crop improvement, through seed multiplication, marketing and distribution, up to the use of the seed by farmers. On the other hand, informal systems consist of farmers who produce their own seed and exchange seed with other farmers. Informal systems tend to generate and maintain less uniform materials adapted to local requirements (e.g. landraces) whereas formal systems tend to be more effective in optimising yield or other desired properties of the crops in conventional farming systems. Combining the strengths from both systems may broaden the genetic basis of PGR in Europe and support the use of wider genetic diversity in the field.

For AnGR most of the European countries report *in situ* and *ex situ* conservation activities for livestock breeds, but there are also gaps in (the breed coverage of) conservation programmes[2]. A wide range of different *in situ* conservation activities has been reported. Conservation of local breeds may be supported, in a limited number of cases, by niche marketing activities, by using local breeds in the management of landscapes and wildlife habitats and in touristic activities, or through the provision of direct financial incentives to the keepers of endangered local livestock breeds. Besides measures to support *in situ* conservation, there is a need to further increase breed coverage and genetic variability within *ex situ* gene bank collections and to support the maintenance of genetic diversity in *in situ* livestock populations. Better involvement of

[2] FAO. 2015. *The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture*, edited by B.D. Scherf & D. Pilling. FAO Commission on Genetic Resources for Food and Agriculture Assessments. Rome (available at http://www.fao.org/3/a-i4787e/index.html).

breeding associations, breeding industry, farmers' networks and other actors in the establishment of gene bank collections should be promoted, and more could be done with regard to the practical utilisation of gene bank collections in breeding and research.

Finally for FGR, dynamic *in situ* conservation (i.e. conservation of evolutionary potential) forms the basis of FGR conservation and *ex situ* conservation complements it. This is true even for superior provenances of economically important tree species, where uniformity is a desired trait, when they may be relatively well conserved *ex situ.* For example through planting and breeding programs as breeders may need to re-sample and infuse later breeding populations, and/ or identify new desired traits in already well-known and adapted populations. In conservation seed orchards, where a large number of trees exchange genes during pollination, and new genetic variants emerge, upon which selection and co-adaptation can act when seed is sown or seedlings raised from this seed planted. On the contrary, static gene conservation conserves only the current state of FGR and involves conservation of individual genotypes (e.g. field clonal archives, in vitro in tissue culture and cryo-preserved embryo culture, and groups of genotypes in long-term seed storage for tree species with orthodox seed storage behaviour (SoW FGR 2014, Kjær et al. 2001). The concept of dynamic gene conservation bridges *in situ* and ex situ conservation.

2 Agenda of the Workshop

The agenda presented below was developed to discuss these challenges. First a plenary session was organised during which one speaker per domain presented specific characteristics and challenges of *ex situ* and *in situ* conservation approaches ("*setting the scene"*).

Then dedicated working groups (one per domain) discussed the issues and challenges for better integration of *in situ* and *ex situ* strategies and identified options for better integration.

The results of each working group were reported during the final plenary session before the general discussion.

8.30 – 9.00	Welcome coffee	
9.00 - 9.15	• Welcome of participants • Reminder of the objectives of the study • Objectives of the workshop	Daniel Traon
9.15 - 9.30	Introduction by the European Commission (DG AGRI)	Emanuela Galleazi
9.30 - 10.30	Setting-up the scene :	
	- *Strengths and weaknesses of ex situ and on-farm/in situ conservation approaches in PGR*	Riccardo Bocci
	- *Strengths and weaknesses of ex situ and in situ conservation approaches in AnGR*	Gustavo Gandini
	- *Strengths and weaknesses of ex situ and in situ conservation approaches in FGR*	Fulvio Ducci
10.30 – 11.00	Coffee break	
11.00 - 11.15	Presentation of the working groups per domain	Sipke J. Hiemstra
11.15-12.30	Working groups discussions per domain (part 1) • PGR • AnGR • FGR	Moderator and rapporteur: Theo van Hintum and Nigel Maxted Sipke J. Hiemstra and Sebastian Winkel Daniel Traon and Marjana Westergreen
12.30-13.45	Lunch	
13.45-14.45	Working groups discussions per domain (part 2)	
14.45-15.45	Reporting of WG discussions focusing on issues and needs	Nigel Maxted (PGR), Sebastian Winkel (AnGR), and Marjana Westergreen (FGR)
15.45-16.45	Discussion (across domains)	All
16.45-17.00	Conclusions and next steps	

3 Summary of the presentations during the initial plenary session (*setting-up the scene*)

The first part of the workshop was dedicated to three presentations that aimed to set the scene. Three experts/scientists from each of the three domains covered during the workshop (AnGR, FGR, and PGR) volunteered to present their view point regarding the relationship between *in situ* and *ex situ* activities and their actors.

The three individual presentations are included in the Annex to this report. Below we present a summary of each of the three presentations.

Strengths and weaknesses of *ex situ* and on-farm/*in situ* conservation approaches in PGR (*Riccardo Bocci – Rete Semi Rurali*)

Plant genetic resources for food and agriculture (PGRFA) are the foundation of agriculture and the basis for breeding and further evolution of varieties. Until recently the conventional system has considered conservation as separate from agriculture, creating adequate gene banks for storing seeds, varieties and genes that are disappearing from farmers' fields.

Seed policies have been developed following the linear approach proposed by Douglas in the '80s, with little space for informal seed systems. Breeding approaches also have been dedicated to uniform varieties for monoculture agricultures not considering marginal farmers or alternative farming systems. In parallel strong policies on intellectual property rights and a seed market more and more concentrated in the hands of few multinationals have reduced the number of cultivated varieties, posing a serious risk for the future of cultivated diversity.

To overcome these problems and the Plant Breeding Paradox (Gepts, 2006); it is important to change paradigm and consider agriculture a place for diversity again, putting together conservation and use of PGRFA and linking *ex situ* to on-farm/*in situ* systems. Creating integrated seed systems will be the challenge that agricultural, seed and conservation policies should address in a supportive and cooperative way.

The ideal legal framework for the implementation of integrated seed systems is the International Treaty on Plant Genetic Resources for Food and Agriculture, which in its articles 5, 6 and 9 paves the way to new policies appropriate for bringing back diversity in the fields.

Finding the right balance for informal and formal seed systems will require building trust between the different actors, finding new ways for protection from misappropriations and maintaining a flow of germplasm based on recognition and reciprocity.

Strengths and weaknesses of *ex situ* and on-farm/*in situ* conservation approaches in AnGR *(Gustavo Gandini - DIVET - University of Milan-UNIMI)*

Considering that definitions might differ across domains, we report those used in AnGR, as proposed by FAO:

- AnGR *in situ* conservation - "*Conservation of a breed through continued use by livestock keepers in the production system in which the livestock evolved or are now normally found and bred*";
- AnGR *ex situ* conservation - "*Includes both 1) cryo conservation of semen, ova, embryos or tissues for potential future use, and 2) the maintenance of live animals (not kept under the conditions referring to in situ conservation)*".

Before the 1990s *ex situ* and *in situ* were generally seen as alternative strategies. Later, the CBD emphasised the importance of *in situ* conservation and now considers *ex situ* conservation to be an essential complementary activity. We are now looking for a better synergy and integration between *ex situ* and *in situ*.

However, we should keep in mind that *ex situ* cryo and live, and *in situ*, differ in their capacity to achieve the different conservation objectives: a) the flexibility of AnGR to meet future changes (including: insurance for changes in production conditions, safeguard against catastrophic events, research opportunities), and b) the sustainable utilisation of rural areas (including opportunities for rural development, maintenance of agro-ecosystems diversity, conservation of rural cultural diversity).

They also differ in their impact on the genetic structure of populations, as opportunities for breed evolution and adaptation, opportunities for increased knowledge of breed characteristics and as exposure to genetic drift. In AnGR, players largely overlap between *in situ* and *ex situ*, with individual farmers and NGOs mainly oriented toward *in situ*. Then, *in situ* and *ex situ* often fall under the same guidance.

Points for discussion include:

- Which ways to better integration being seen from *in situ* and from *ex situ* sides?
- Should we have better exchanges across animal, forest, microbial, plant GR sectors?
- Should AnGR conservation become more global (European vs./+ Country)?
- Should cryo material become a major conservation tool for *in vivo* management,
- How to secure that *in situ* provides more guidance to *ex situ*? When is that really needed?

Strengths and weaknesses of *ex situ* and on-farm/*in situ* conservation approaches in FGR *(Fulvio Ducci – Forestry Research Centre - CRA-SEL Arezzo, Italy)*

The presentation focused on forestry particularities in the Mediterranean region which provides great environmental variation and great biodiversity. This environment is composed of twice the number of wood species than found in central and northern European forests (246 vs. 135) of which 34 are exclusive to Mediterranean forests. Most forest biodiversity is located in southern hot spots where forest trees have resisted climate changes throughout the Pleistocene.

They represent a valuable and original source of genetic variation for adaptation and mitigation strategies in the overall context of climate change the main consequence of which is the shift of climatic zones either in latitude or in altitude. These changes require new approaches to manage FGR in particular in silviculture, production and trading of Forest Reproductive Material (FRM), and in conservation of FGRs.

FGRs may respond to climate change in various ways:

- Migration to track the geographical shift of suitable environmental conditions;
- Acclimation through phenotypic plasticity which has been demonstrated to be an efficient response mechanism to (climate) change even if spontaneous migration potential is considered as (to) slow to respond to evolution;
- Evolutionary adaptation which can be very rapid: e.g. over only a few generations, increased drought resistance and growth in *Cedrus atlantica* in France and epigenetic-based shifts in bud break phenology in *Picea abies* in Norway; and
- Changes in the forest community, in demography and ecological interactions.

In that overall context, the following management approaches should be followed and intensified:

- **Monitoring genetic diversity and adaptability**. It is strongly needed to monitor the population dynamics for tree genetic diversity, adaptive traits and to detect changes in them;
- **Re-thinking forest reproductive materials (FRMs) management** with special care to seed zone delineation and provenance selection;
- **Developing Assisted migration methods**. Many valuable FGR may be unable to migrate to suitable habitats and could go locally extinct. Assisted migration can be a pragmatic solution;
- **Changing density and species composition *in situ***. FGRs can be managed to reduce the vulnerability of forest plant communities or to aid their recovery;

- **Safeguarding marginal population (MaP)** FGRs may be most important but socially problematic at low elevations, where human impacts can be intense; and
- **Creating FRMs in breeding programmes:** Common gardens are both models for understanding local adaptation and phenotypic plasticity and tools for selecting newly adapted materials.

All these actions should be implemented taking into considerations that the best adapted FRM of today may not prove to be the best adapted FRM of tomorrow under climate change.

4 Conclusions of the Working Groups

After the initial plenary session, the participants were invited to join one of the three Working Groups according to their domain expertise to discuss integration issues between *in situ* and *ex situ* per domain. The main conclusions of each of the three WGs are presented below.

4.1 Working Group on PGR

The WG started with a short tour de table to invite each participant to indicate his/her main expectations regarding the WG. Then a SWOT analysis was developed and participants made suggestions on how to remove the barriers for integration of *ex situ* and on-farm/*in situ* systems.

The following issues were mentioned during the discussion:

- Social context of on-farm and measurement of success (tools or strategies required to help implementation);
- On-farm conservation, use and development of "*new*" resources (e.g. other species, other rare breeds), decentralised *ex situ* (community gene bank);
- Policy context to bring actors together and recognise mutual trust and benefit;
- Gap analysis as a means of bringing together the *ex situ, in situ* and on-farm communities, and work together to implement systematic conservation and use;
- Establish and Improve inventories and databases of PGR material;
- Firm EU / national policy basis for in / *ex situ* / on-farm conservation and links between communities, legislation for *in situ* and marketing of diversity;
- Significant diversity held by single farmers which should be conserved in / *ex situ* / on-farm, use of landrace (development added value), reintroduction of material;

- Lack of knowledge of diversity in crop and agro-environment, how to collate knowledge of diversity and network farmers, which landraces to grow, develop conditions of trust;
- Need to be clear about what is meant by diversity, focus of genomic work to benefit farmers, get material out of gene bank and back to farmers, make better links between breeders and farmers networks, landrace loss must be addressed;
- Particular problem of fruit tree on-farm conservation, for example *in situ* divides between agricultural and environmental implementation, need to bring on-farm into Protected Areas (PAs) sites, develop new markets for landraces and crop diversity;
- Looking for unique traits associated with on-farm production and legislation for marketing (badging of products);
- Linkage of relative value of resources, linked information system for in / *ex situ* / on-farm, bring in link to ornamental species and ecosystem services;
- Improve tools for characterisation and link to use, work on broader crop base (minor crops), review legislation and fill gaps (uniform application of conservation variety legislation, universal on-farm conservation versus key sites), not only national issue must marry national with regional / global context; and
- Improved communication with all stakeholders (particularly gene banks), more active dissemination of materials to farmers (including predictive characterisation and evidence-based databases but beware of IPR issues for farmers).

After this initial thought, the group reflected on the Strengths, Weaknesses, Opportunities and Threats (SWOT) that can be summarised as follows. The group then developed the ideas came up into strengths, opportunities, weaknesses and threats.

The following points have been considered as strengths:

1. Existing tools and methodologies to bridge gaps between communities and locating adaptive traits (e.g. informatics, predictive characterisation, gap analysis);
2. Existing networks in place (seed, gene bank, PA networks) which share common objectives;
3. Reintroduction of genetic material from *ex situ* to on-farm already occurs, allowing study of Genotypes by Environment by Systems (GxExS) interactions;
4. There is a global policy base (ITPGRFA Art 5 / 6); and
5. ECPGR coordination platform.

On the contrary the following weaknesses have been identified:

1. Lack of relevant information for use by farmers (e.g. adaptive information, heterotic groups, phenotypes);
2. Heterogeneity and lack of clarity in terms of access and benefit sharing and distribution policy for *ex* and *in situ*;
3. Material released by gene bank is too small for farmers use without bulking up;
4. Language problems restrict use of PGRFA;
5. Existing linkage between seed, gene bank and other networks are weak due to lack of understanding, will and resources;
6. Imbalance between expenditure of public funding related to informal on-farm networks;
7. Lack of transdisciplinary networks to bridge the gap between on-farm research, implementation, food chain and policy;
8. Limited representation of horticultural, ornamental and minor crops;
9. Unknown impact of climate change on various *in situ* and on-farm conservation techniques and use;
10. Different understanding of plant evolution between different communities;
11. Different culture of the different actors (formal / informal approach difference).

In relation to the above-mentioned strengths and weaknesses the participants saw the following opportunities:

1. Appropriate policies can stimulate landraces growth by farmer;
2. Improving the communication between communities leads to better use of material held in gene banks;
3. Potential use of *ex situ methodology and* infra-structure to back-up *in situ* diversity and provide security for climate change and other events;
4. Potential use of *in situ* community to promote take-up of diversity by farmers;
5. Build on on-farm demonstration and lobbying ability to assist broader PGR conservation and use;
6. *In situ*, on-farm and *ex situ* PGRFA working together provides thorough phenotype data;
7. *In situ* and on-farm PGRFA enables a facilitated regeneration of *ex situ* material;
8. *In situ* and on-farm PGRFA enables recombination / adaptation of *ex situ* material;

9. A better coordination and communication between *in situ, ex situ* and on-farm can demonstrate the value of PGRFA;
10. Involve urban and periurban farming[3] within scope of actors.

Finally, several threats have been identified which mainly related to:

1. Existing perverse policies and lack of policies can hinder conservation and use (e.g. implementation of seed and ABS legislation);
2. GMO issues may block access / use of PGRs by on-farm communities and others;
3. Patents on PGRFA may limit their usage and further innovation;
4. Loss of diversity held on-farm due to natural wastage of maintainers;
5. Climate change can pose serious risks to *in situ* and on-farm approaches;
6. Uncertainty over long term funding of PGRFA activities.

In conclusion, it is important to note that the participants brought to attention that the integration of *ex situ* and on-farm/*in situ* systems has significant strengths and opportunities but also some identified weaknesses and threats that need to be addressed. The sustainable use of PGRFA to benefit European communities should be promoted through the following actions:

1. Creating structures and policies that facilitate the development of all identified opportunities;
2. Facilitating the publication / portal for grey literature in some form (hard copy, website, etc.);
3. Promoting a better day-to-day integration between ECPGR and seed networks;
4. Increasing cross sectorial projects involving *ex, in situ* and on-farm communities (creation of a new platform, H2020, new GenRes);
5. Reviewing of policies and their resourcing impacting PGR at the European, national and regional levels;

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[3] Urban Agriculture spans all actors, communities, activities, places, and economies that focus on biological production in a spatial context, which—according to local standards— is categorised as 'urban'. Urban Agriculture takes place in intra- and periurban areas, and one of its key characteristics is that it is more deeply integrated in the urban system compared to other agriculture. Urban Agriculture is structurally embedded in the urban fabric; it is integrated into the social and cultural life, the economics, and the metabolism of the city.
Source: COST Action TD1106 and that will be publish soon http://www.urbanagricultureeurope.la.rwth-aachen.de/

6. Facilitating the further integration of *ex situ, in situ* and on-farm communities through cross-sectorial representation in routine sectorial meetings;
7. Developing tools and protocols to promote use of PGR;

Finally all the participants agreed on the fact that the discussion was just started and not yet concluded, and maybe a second workshop is required within the project.

4.2 Working Group on AnGR

The moderator briefly explained the objectives of the working group meeting for the AnGR domain, to discuss issues and problems to be addressed for better integration of *ex situ* and *in situ* strategies. Then, participants explained their background, interests and expectations of the meeting of the AnGR Working Group. Key issues and topics were identified, followed by an in depth discussion of strengths, weaknesses, opportunities and threats (SWOT). On the basis of the SWOT analysis, the Working Group on AnGR identified conclusions and recommendations for better integration of *in situ* and *ex situ* strategies which are presented per topic below.

Current level of integration of ex situ and in situ conservation

In the AnGR domain *ex situ* conservation is generally accepted as an important complementary strategy to *in situ* conservation (FAO Global Plan of Action on AnGR, 2007). In European countries, there are many positive examples at single breed level where both approaches are well integrated. But also often a systematic, integrated approach is lacking. Stronger collaboration between the different (*in situ* and *ex situ*) actors could make conservation of AnGR more effective and efficient. The level and type of integration will always differ between species and countries, because of technical and institutional conditions or limitations. The AnGR working group stated that it is important to further raise awareness (e.g. through ERFP) on the need for integration of *in situ* and *ex situ* measures for the purpose of long term conservation and sustainable use of AnGR. Tailor-made integrated strategies should be further developed and implemented by relevant actors at local and national level. The demand for (available) *ex situ* material by *in situ* stakeholders should be identified alongside the public interest to conserve genetic diversity in the long run. In particular stakeholders receiving public support for *in situ* conservation may be expected also to contribute to long term *ex situ* conservation measures.

Conservation priorities

An integrated *in situ/ex situ* conservation strategy requires a common understanding of conservation priorities at local, national and European level. Currently neither *in situ* nor *ex situ* conservation strategies have a high priority in national policies. Moreover, stakeholders or user groups may have different interests resulting in different conservation priorities. There is a need to more explicitly prioritise conservation measures at different levels: local, national and European. This is important to make

implementation of conservation strategies more efficient and to spend public resources more effectively.

Standards and legislation

At EU level the zootechnical and sanitary legislation form the primary regulatory framework for conservation and sustainable use of AnGR. This type of legislation should facilitate intra-community exchange of farm animal genetic resources, and at the same time contribute to the conservation of farm animal genetic resources. Sanitary legislation is sometimes too restrictive, and sometimes a threat, for the management of rare/local breed populations at national level. An integrated *in situ* and *ex situ* conservation strategy sometimes requires specific derogations from EU sanitary legislation and specific operational standards at national level.

Involvement of farmers and livestock keepers in conservation strategies

Farmers and livestock keepers are the key actors in *in situ* conservation of farm animal genetic resources. Without active farmers, breeders and their networks/breed societies, a breed cannot survive. Therefore first priority should be given to *in situ* conservation, which should be complemented by *ex situ* conservation measures. Farmers' networks and breed societies should be fully integrated in *ex situ* conservation programmes. In particular ownership issues and farmers rights should be properly reflected in Material Acquisition and Material Transfer Agreements used by gene banks. Rights of farmers and breeders should be properly balanced with long-term public interests.

Identification and recognition of rare/local breed populations

Farm animal breeds in the EU are officially recognised through their breeding associations, following the EU zoo-technical legislation. However, the EU zootechnical legislation currently does not provide a clear legal definition of the term 'breed' or 'rare breed'. Some of the breeds in Europe are categorised *"at risk"* and reported by National Coordinators to the European (EFABIS) and global (DAD-IS) databases. Member States can also decide which rare breeds within the country are eligible for financial support under their Rural Development Programme. At the same time a substantial number of livestock populations have not been identified, defined, registered or recognised yet, and criteria to determine breed status and breed categories also vary among the Member States. A better coordinated and integrated *in situ* and *ex situ* conservation approach could motivate farmers, breeders' networks and local/national authorities to register and to recognise the breed, and to take it into consideration for prioritisation and support. Non-coordinated conservation measures for breeds with unclear status could cause less optimal use of funds and efforts to conserve farm animal genetic diversity

Interests and responsibility of the breeding industry

A relatively small number of specialised, commercial breeds dominates the production of livestock products in Europe and globally. The breeding industry is primarily

interested in productivity and performance of these breeds, but at the same time they take part of the management of genetic diversity within their breeding populations. The breeding industry is less interested in (*in situ* and *ex situ*) conservation of local/rare breeds, because the multi-functionality of local breeds usually does not fit in their current business model. On the other hand, the breeding industry sometimes supports the long term conservation of farm animal genetic diversity and should be encouraged to share their knowledge. Public-private partnerships should be further explored to share responsibilities in conserving farm animal genetic diversity and to ensure access to genetic resources in the long run, both for breeding and conservation purposes. There is a trend that data related to particular genetic resources becomes more important than the genetic resources itself. Better characterisation of AnGR kept *in situ* or *ex situ* is therefore as important as the genetic resources, from the perspective of both conservation and breeding, and could be interesting for a public-private partnership.

On the basis of these main conclusions, the following general recommendations have been made:

- Need for further development of integrated (*in situ* and *ex situ*) strategies for AnGR, to be jointly implemented by relevant stakeholders;
- Further prioritisation of conservation efforts, associated with dedicated funding, at national and European level;
- Improvement and revision of existing legislation at EU level and national level to facilitate the conservation and sustainable use of AnGR;
- Avoidance of implementation of integrated conservation strategies without active involvement of farmers' networks or breed societies;
- Improved monitoring and recognition of breeds at European level, to take into consideration for prioritisation and conservation support measures;
- Development of public-private partnerships between breeding industry and government to support the long-term conservation, characterisation and exploitation of farm animal genetic resources.

4.3 Working Group on FGR

The working group started by an introduction during which participants were invited to present themselves, their activities and their main expectations as regards the working group discussions.

This introduction led to the identification of several specificities of the FGR in comparison to other GR domains. These specificities are presented below followed by the results of the SWOT analysis. Then a series of recommendations regarding FGR are made.

Forest trees are long lived sessile organisms with long generation times. They are still mainly undomesticated as the first breeding programmes (for a short list of species, mainly conifers) started in 1930s and 1940s and breeding cycles are long (up to 30 years). Apart from economic function (wood production) forests also fulfil numerous environmental and societal functions.

The ability to adapt to changes in the environment (changes in temperature and precipitation patterns, emerging pathogens…) is extremely important for long lived organisms such as forest trees and woody shrubs. For that, the trees need enough genetic variation to be able to adapt through continuous 'selection of the fittest' and co-adaptation of host-pathogen systems and other complex biological interactions (Kjær et al. 2001; Byrne 2000). In forestry, this is also termed dynamic gene conservation, and includes primarily *in situ* conservation. Dynamic *in situ* conservation forms the basis of FGR conservation and *ex situ* conservation complements it. This is true even for identified, superior provenances of economically important tree species, where uniformity is a desired trait, when they may be relatively well conserved *ex situ*, e.g. through planting and breeding programs as breeders may need to re-sample and infuse later breeding populations, and/ or identify new desired traits in already well-known and adapted populations (SoW FGR 2014).

However, in special cases, *ex situ* conservation can also be considered dynamic. In conservation seed orchards, where a large number of trees exchange genes during pollination, and new genetic variants emerge, upon which selection and co-adaptation can act when seed is sown or seedlings raised from this seed planted. On the contrary, static gene conservation conserves only the current state of FGR and involves conservation of individual genotypes (e.g. field clonal archives, in vitro tissue culture and cryo-preserved embryo culture, and groups of genotypes in long term seed storage for tree species with orthodox seed storage behaviour). The concept of dynamic gene conservation bridges *in situ* and *ex situ* conservation.

Dynamic gene conservation does not exclude forest management and forests that serve as dynamic gene conservation units (*in situ* conservation), can and are managed to fulfil all other functions (production, environmental, societal). However, management is primarily a tool to ensure adequate regeneration of such units to persist through time.

In forestry, the main source of seed for regeneration comes from *in situ* seed stands. For some species (mainly conifers like Norway spruce and Scots pine) seed is also collected in seed orchards resulting from breeding programs.

The results of the SWOT analysis as regard *in situ* vs. *ex situ* collections in FGR can be summarised as follows:

	Strengths/opportunities	Weaknesses/Threats
In situ	• Coordinated European effort through EUFORGEN • An existing network of dynamic gene conservation units, following the same minimum criteria for selection, exists and is kept in the EUFGIS database hosted by EUFORGEN	• Difficulties in finding stands to complement the existing *in situ* network, especially for minority species (ownership, lack of awareness among forest owners, economic interests) • Privatisation of forests, nurseries and breeding – profit is the main driver; however forests provide multiple environmental and societal functions that need to be considered • Effect of climate change & management practices on genetic diversity through time still largely unknown
Ex situ	• Directive on FRM includes four categories of FRM: (i) source-identified; (ii) selected; (iii) qualified; (iv) tested, (already bridging *in situ* and *ex situ* conservation and use), and ensures traceability of the collected seed; countries can add additional species to the species list for which the directive applies • Genetic diversity of the forest stands selected as seed stands is controlled and follows a set of criteria	• Collections declining due to lack of funding, knowledge (knowledge is not transferred to the next generation of people working with seed banks, provenance trials, conservation seed orchards,…), lack of or low interest among policy makers at national and international levels • Range of species currently conserved is small; recalcitrant (and intermediate) seed is difficult or impossible to save with current knowledge/technologies • It is expensive to collect seed from a sufficient number of trees (minimally 50) to ensure an adequate level of genetic diversity in the seed lots for conservation & use and current practices often do not follow the recommendations fully, collecting seed from a small number of trees potentially diminishing genetic diversity • Efforts not coordinated; therefore repetitions of same efforts occur

This analysis led to the identification of several recommendations and needs that can be summarised as follows.

- **Strengthen seed testing capacities and knowledge**: In the last decades seed testing capacities (number of ISTA certified laboratories, personnel) and knowledge have diminished mainly due to the lack of funding. In the face of

possible assisted migration and new pathogen threats we urge to re-establish former capacities for seed testing.

- **Research on recalcitrant (and intermediate) seed behaviour**: *Ex situ* conservation of species with recalcitrant seed through seed storage is hampered because the lack of knowledge of seed physiology and storage conditions for such seed.
- **Intensification of the effort to conserve (both dynamically and statically) and use FGR of marginal and peripheral populations** (both leading and rear edge of the distribution range). These populations might contain adaptive variation that could be potentially used under climate change.
- **Review of practice behaviour of seed and seedling handling of FRM in nurseries** is needed; traceability of seedlings needs to be improved (to avoid spread of diseases through seedlings, i.e. ash dieback and prevent decline of future forest stand due to use of un-appropriate provenances).
- **Implement forest genetic monitoring** (monitoring of selection, genetic diversity and mating system) in dynamic gene conservation units (*in situ*). Forest genetic monitoring includes a prognostic value and forms a method to secure conservation of processes that maintain genetic variation in natural populations).
- **Compare economics of *in situ* and *ex situ* conservation**; define and test appropriate indicators (build upon the Economics of Ecosystems & Biodiversity-TEEB indicators[4]).
- **Complement the existing network of dynamic gene conservation units.**
- **Promote conservation of seed orchards.**
- **Define ABS for FGR.**

Finally, a few additional ideas popped-up during the working group:

- Does conservation and use of FGR include only forestry trees (i.e. economically important), forest trees or all forest woody species (trees and shrubs)?
- Should we conserve more genotypes from fewer species or fewer genotypes from more species?
- Revitalisation of old provenance trials (assessments beyond juvenile tree stage) is needed to obtain data for modelling and delineating provenance regions at a European level for transfer of FRM (also in the light of assisted migration).

[4] See : http://www.teebweb.org/

5 Conclusions

Participants acknowledged their satisfaction as regards this type of event and indicated their interest for further work and exchanges bridging communities and types of actors for the development of consistent and complementary actions at EU level. Several arenas have already discussed this issue of integration between *in situ* and *ex situ* but, according to several participants, these exchanges were too fragmented. In several cases they were discussed per domain and not across domains, and in other cases exchanges were limited to the scientific community only. A multi-disciplinary approach linking science, agriculture/forestry and policy is required.

The audience widely discussed the need to discuss this integration issue across domains. When it was recognised that each of the 3 domains is highly specific in term of e.g. overall structure, equilibrium between *in situ* and *ex situ*, equilibrium between conservation and use, number and type of actors in the "*GR Chain*", role of each actor, R&D technologies being used; several participants appreciated having a cross domain exchange which led to identifying "*new ideas*" for a given area. This aspect needs looking in more detail in the future, perhaps particular in technical aspects of gene banking and on-farm.

The majority of the participants agreed that the interface between *in situ* and *ex situ* conservation has to be improved but it was recognised that this is a complex issue that it mainly needs to be tackled per domain. These specificities have to be recognised and considered in any EU policy approach by decision makers. The establishment of domain Task Forces to look into this would be beneficial.

On the top of purely technical/scientific recommendations specific to specific domains, the following proposals that have been made by the three working groups highlight several additional policy/regulatory needs:

- The overall EU policy context and its link with the international initiatives (e.g. FAO) shall encourage exchanges between actors in order to recognise mutual trust and benefits;
- Improved communication with all stakeholders all along the food chain and forestry's to secure that genetic resources issues are fully recognised as a basis for food production and sustainable forest use for production, environmental and societal functions. The same regulatory framework shall stimulate the use and cultivation of landraces and rare breeds by farmers/producers;
- Appropriate and balanced funding for in *in situ* and *ex situ* activities, reflecting their respective contributions in the different domains;

- Establish and improve national and regional inventories and databases of existing GR material is necessary to provide a sound foundation GR conservation and use;
- Transdisciplinary networks to bridge the gap between on-farm research, implementation, food chain and policies. For FGR these transdisciplinary networks would need to bridge research, implementation (forest management) and policies;
- Climate change issues have to be fully considered as serious threats especially in the case of FGRs, but also *in situ* and on-farm PGRs;
- Improved monitoring and recognition of breeds and landraces at European level, to take into consideration for prioritisation and conservation support measures.

All in all, the conclusions of each of the working groups have highlighted numerous needs in all areas dedicated to conservation and use of GR. Even though improvements have been observed since the establishment of the EU coordination platforms (ECPGR, ERFP, EUFORGEN), there is still significant improvements to be made as regards the current level of integration between *in situ* and *ex situ* conservation.

Another idea was the mapping of the linkages between in situ conservation across all sectors. Crop wild relatives and FGR in situ conservation areas may overlap with Natura 2000 sites, and breeds-at risk are grazing in high-nature value farmland and Natura 2000 sites. However, no mapping of spatial distribution of AnGR, PGR and FGR in nature conservation sites in Europe exists so far. It was proposed that the EEA and research organizations should collaborate to generate such maps.

ANNEX 1: List of participants

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