www.pgrsecure.org

Project acronym: PGR Secure

Project Full Name: Novel characterization of crop wild relative and landrace resources as a basis for improved crop breeding

Final Report

Section 4.1: Final publishable summary

Contents

4.1.1 Executive summary 3

4.1.2 Project context and objectives 4

4.1.3 Main scientific and technological results/foregrounds 6

Theme 1: Novel characterization techniques 6

Theme 2: Crop wild relative and landrace conservation 12

Theme 3: Improved use of CWR and LR by breeders 18

Theme 4: Informatics 21

4.1.4 Potential impacts of the PGR Secure action 23

Socio-economic impact and wider societal implications of the action 23

Exploitation of project results: breaking through the scientific and industrial state of the art 24

Dissemination activities 25

Sustainability of project results 27

4.1.5 Project website and contact details 36

4.1.1 Executive summary

The PGR Secure action, 'Novel characterization of crop wild relative and landrace resources as a basis for improved crop breeding' was undertaken to address the pressing need for greater genetic diversity in European crops to mitigate the potentially devastating impacts of climate change on the agri-environments in which they grow. Extreme weather events resulting from climate change have already resulted in significant economic losses in the EU agricultural sector amounting to billions of euros. There is an urgency to breed more resilient crops and to find ways of speeding up the plant breeding process to provide a buffer against unpredictable climatic changes.

The particular value of crop wild relatives (CWR – plant species closely related to crops) and landraces (LR – locally adapted, genetically diverse crop varieties) for crop improvement has long been recognized. However, their conservation has been largely neglected and their full utilization has been hampered by insufficient knowledge of their diversity; lack of characterized germplasm collections; unavailability of information on potentially useful material and specific traits; difficulties associated with the time taken to breed uniform and stable crops utilizing wild species; and problems of access to plant material due to the political issues of sovereignty and benefit-sharing.

Like other wild species, CWR are threatened by a range of human-induced pressures on their native habitats, including climate change. Historically, many LR varieties have been lost (and continue to be lost) due to replacement with high yielding varieties, changing consumer preferences and expectations, and socio-economic circumstances impacting on LR growers. Without a systematic strategy for conserving CWR and LR diversity, many populations will continue to suffer genetic erosion (loss of unique traits) and may even face extinction. There is an imperative to conserve these resources *in situ* (i.e., in their native habitats or where they have adapted to local conditions) to allow continuing natural evolution through adaptation to changing environmental conditions. There is also the need for safety *ex situ* storage in gene banks where they can be characterized and made available for crop improvement programmes.

Actions undertaken by the PGR Secure consortium have resulted in the development of an integrated approach to the conservation of these important resources which combines national and regional conservation strategies. However, conservation is only one part of the story. In order to overcome the obstacles to their effective utilization, the complexity of procedures for breeders obtaining material and the barriers to the use of exotic diversity (i.e., plant material that is more difficult to utilize in conventional breeding programmes) need to be addressed. PGR Secure brought the European PGRFA stakeholder community (genebanks, public research institutes, commercial plant breeding companies, agro-NGOs and governmental bodies) together to better understand their needs and to identify ways to improve the links between conserved CWR and LR resources and their use in crop improvement. The project also developed novel tools and methods to identify traits of interest to plant breeders and to speed up the breeding process, as well as to improve access to CWR and LR conservation and utilization data.

Achieving effective conservation and use of European CWR and LR diversity as a means to promote food and economic security requires coherent, regionally coordinated policy and the appropriate resources for their conservation, characterization and evaluation. The PGR Secure consortium has taken the first steps towards achieving this aim by providing a solid scientific and technological foundation to underpin policy development, the maintenance of food security and to safeguard Europe's agricultural economy.

4.1.2 Project context and objectives

Introduction

Our food depends on the continued availability of novel sources of genetic variation to breed new varieties of crops which will thrive in the rapidly evolving agri-environmental conditions we are now faced with as a result of climate change. Wild plant species closely related to crops (crop wild relatives, or CWR) and traditional, locally adapted crop varieties (landraces, or LR) are vital sources of such variation, yet these resources are themselves threatened by the effects of climate change, as well as by a range of other human-induced pressures and socio-economic changes. Further, while the value of CWR and LR for food security is widely recognized, there is a lack of knowledge about the diversity that exists and precisely how that diversity may be used for crop improvement. This is despite the importance of these resources being recognized in a number of policy instruments, including the FAO Global Plan of Action for the conservation and sustainable use of PGRFA[1] (GPA), FAO International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), CBD Global Strategy for Plant Conservation, CBD Strategic Plan for Biodiversity 2011–2020, and European Strategy for Plant Conservation. PGR Secure aimed to address these issues by: a) developing fast and economic methods to identify and make available genetic material that can be used by plant breeders, for example to confer resistance to new strains of pests and diseases and tolerance to extreme environmental conditions such as drought, flooding and heat stress—the biotic and abiotic pressures which are rapidly evolving and having an increasingly detrimental effect on crop productivity; and b) developing a Europe-wide systematic strategy for the conservation of the highest priority CWR and LR resources to secure the genetic diversity needed for crop improvement; and c) ensuring that conserved diversity is made available to users in a manner that facilitates their ease of use.

PGR Secure context: a step change in agrobiodiversity conservation and use

The EC Biodiversity Action Plan for Agriculture (www.epbrs.org/PDF/EPBRS-IR2004-BAP%20Agriculture.pdf) highlighted the need for a step change in crop cultivar production in Europe to ensure food security across the continent, particularly in light of the adverse impacts of climate change on crop yields, as well as to respond to rapidly changing consumer demands. If these requirements are to be met, plant breeders need a broader pool of diversity to supply the necessary range of traits, as well as greater efficiency in characterization and evaluation techniques to locate the desired traits and speed up the production of new varieties. The Action Plan also argued that maintaining the *status quo* for agrobiodiversity conservation and use is no longer tenable and that a step change in systematic conservation and use is also required. The two major components of agrobiodiversity that offer the broadest range of diversity for breeders are CWR and LR, but there is currently a gap between their conservation and their use and they remain under-exploited by the user community. In order to meet the needs of future generations, there are four key areas that need to be addressed: 1) development of novel approaches to characterization and evaluation to replace traditional resource intensive phenotypic methods; 2) systematic active *in situ* and *ex situ* CWR and LR conservation; 3) understanding the needs of the user communities and current constraints in the use of CWR and LR in crop improvement programmes; and 4) improved CWR and LR information management and accessibility.

[1] Plant genetic resources for food and agriculture

PGR Secure: answering the call

The overarching goal of PGR Secure was to underpin European food security in the face of climate change by advancing CWR and LR diversity conservation and use. To achieve this goal PGR Secure had four research themes: 1) novel characterization techniques, 2) CWR and LR conservation, 3) improved use of CWR and LR by breeders, and 4) informatics (see Figure 1). The objectives of themes 1 and 3 were to improve breeders' use of conserved CWR and LR diversity by a) applying novel characterization techniques such as genomics, transcriptomics, metabolomics, high-throughput phenotyping and GIS-based predictive characterization, and b) engaging the plant breeding community in a dialogue to identify exactly what is needed to bridge the conservation/use gap and to facilitate the flow of material from conservation facilities to breeders. The objectives of themes 2 and 4 were to enhance CWR and LR species and genetic diversity conservation through the development of CWR and LR inventories and systematic conservation strategies, and to improve the management and accessibility of CWR and LR conservation and trait data.

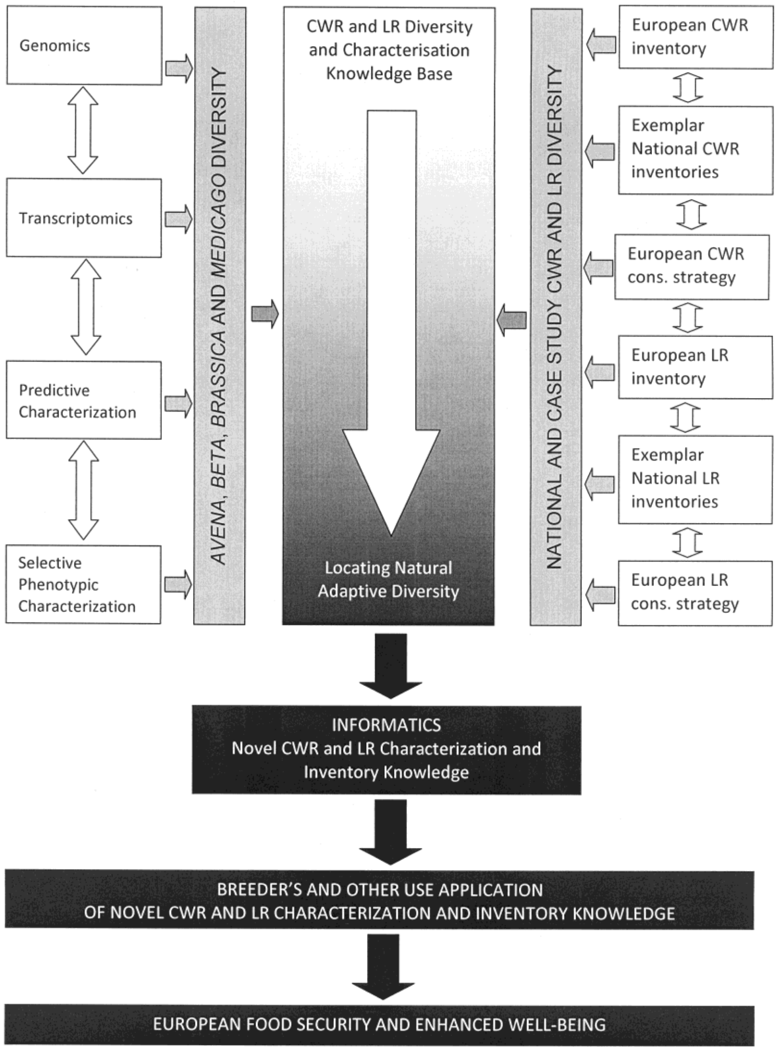

Figure 1. Schematic diagram of interrelated project themes

4.1.3 Main scientific and technological results/foregrounds

The scientific and technological results of the project fall under four themes: 1) Novel characterization techniques; 2) CWR and LR conservation; 3) Improved use of CWR and LR by breeders; and 4) Informatics.

Theme 1: Novel characterization techniques

Actions undertaken under Theme 1 have resulted in enhanced techniques to identify useful adaptive traits to support plant breeding. The research involved two components: a) phenomics and genomics and b) predictive characterization.

Phenomics and genomics

Brassica crops, in particular Brussels sprout, kale and Savoy cabbage suffer from a range of insect pests, including the cabbage aphid (*Brevicoryne brassicae* – Figure 2) and whitefly (*Aleyrodes proletella*), which are difficult to control and growers would therefore benefit strongly from resistant varieties. In the PGR Secure project we aimed to: 1) identify novel sources of host plant resistance to the cabbage whitefly and cabbage aphid; 2) elucidate the resistance mechanism; and 3) provide tools to breeders that will facilitate resistance breeding.

Figure 2. Susceptible brassica leaf with heavy infestation of cabbage aphid. Photo: J. Pritchard

Novel sources of resistance

The application of a novel high throughput method for phenotyping genebank accessions of *Brassica* species has led to the identification of accessions resistant to the cabbage aphid and the cabbage whitefly. Accessions resistant to whitefly were identified among *B. oleracea* var. *capitata* (heading cabbage) landraces and their wild relatives, *B. villosa* (Figure 3), *B. incana* and *B. montana*. Whereas in heading cabbage the resistance is only expressed in plants of at least ten–twelve weeks old, some wild relatives were already starting to express resistance at six weeks. Since farmers plant these crops at an age of 5–6 weeks this earlier expression of resistance is of great practical importance. Some level of resistance to the cabbage aphid was observed in *B. fruticulosa* and in *B. villosa*. With the resistant accessions identified, plant breeders now have a resource that can be used to develop high yielding varieties that are resistant to the cabbage whitefly and aphid.

Figure 3. *Brassica villosa* subsp. *bivoniana* pictured with clip cage containing whiteflies in field trials for plant host resistance, Wageningen, The Netherlands. Photo: K. Pelgrom

Resistance mechanism

Host plant resistance to phloem-feeding insects can be mediated by several mechanisms. Plants can defend themselves against phloem-feeding insects by means of physical and chemical barriers. Resistance components can be present in the form of morphological adaptations, such as trichomes (leaf hairs) or wax layers on the surface of the leaf, but may also be present in deeper cell layers or in the phloem itself. The Electrical Penetration Graph (EPG) technique was used to obtain information on the presence and location of resistance factors. From the EPG readings it is possible to determine the time an insect needs to reach the phloem and where on the way to the phloem they encounter resistance from the plant. EPG readings also contain information on how long aphids are actually taking up phloem sap. Using this technique we could show large differences in feeding behaviour of cabbage aphids on different *Brassica* accessions. Aphids had difficulties to reach the phloem on some accessions of *B. villosa*, *B. incana* and *B. montana*, whereas they had no problems doing this on some *B. oleracea* accessions. All accessions of *B. villosa* and one *B. incana* accession were densely covered with trichomes, which may explain at least some of the resistance observed.

Secondary metabolites can also play an important role in the defence against herbivores. To identify metabolites possibly involved in the resistance against whitefly we performed metabolomics analysis on two sets of plant material with contrasting levels of whitefly resistance (resistant vs. susceptible). One set consisted of cabbage landraces and another set of heading cabbage genotypes derived from a segregating population. Two complementary metabolomics platforms were used to identify compounds related to susceptibility and resistance—Gas Chromatography-Mass Spectrometry (GC-MS) and Liquid Chromatography-Mass Spectrometry (LC-MS)—in both negative and positive ionization modes. Both the GCMS and LCMS data showed no significant differences in metabolites between the resistant and susceptible groups. Based on this result it is unlikely that the resistance in heading cabbage is based on a metabolite. Other mechanisms which may be based on a protein are more likely, although it cannot be excluded that a metabolite not detected by any of the platforms used is the causal agent.

We also studied differential gene expression in different landraces and species of *Brassica* to obtain information about candidate genes underpinning resistance factors, which may also help to identify resistance mechanisms. Differences in gene expression were seen in the sets of material previously classified as resistant or susceptible to aphids based on EPG or field evaluation of resistance. The gene expression analysis was carried out on plant materials with or without prior infestation with the cabbage aphid. In the plants that received an infestation, genes that are induced by aphid infestation will also show up. Differentially expressed genes were seen in almost every grouping of resistant and susceptible plants that were considered (e.g., based on the field evaluation or on the different EPG parameters). Different sets of genes were revealed by the different groupings, which may point to the different mechanisms active during the various phases in an aphid infestation. The differentially expressed genes are considered candidate genes for resistance. Some of them have already been implicated in resistance to aphids in the literature, but most of them are new (i.e., not previously associated with aphid resistance). Further research will be needed to establish and validate their exact role in resistance and to identify the alleles that contribute most to the resistance.

Tools to facilitate resistance breeding

Molecular markers are an indispensable tool for modern plant breeders. They are used to make early selection of plant material possible, for the introgression of genes/alleles without a clear phenotype, for stacking several alleles with a positive effect, and to facilitate recurrent parent selection. The marker type most widely used today is the Single Nucleotide Polymorphism (SNP) marker. We obtained SNP markers that are informative in *B. oleracea* and its wild relatives by sequencing the leaf RNA of 15 selected plants, resulting in the identification of c. 2 million SNPs. From these SNPs a selection was made based on the position of the SNP on the *B. oleracea* reference genome and their origin. Finally a 90k Affymetrix Axiom array was produced which contains c. 40,000 SNPs selected from a set of broccoli varieties, 21,000 polymorphic SNPs from a set of heading cabbages, 4200 already validated *B. oleracea* SNPs and approx. 5000 SNPs that are polymorphic between *B. oleracea* and the wild relative *B. incana,* as well as 5000 that are polymorphic between *B. oleracea* and *B. montana.* The array also contains c. 5000 SNPs that are polymorphic within *B. fruticulosa.* The array will be very useful in a number of applications including QTL mapping in *B. oleracea* and its wild relatives, association mapping in *B. oleracea*, as well as relationship analysis among (sub)species, varieties and landraces. The array is expected to significantly decrease the time needed to develop a new variety in a range of brassica crops.

To facilitate an efficient use of the novel sources of resistance that were identified, we studied the genetics of the resistance. Quantitative trait loci (QTL) and linkage disequilibrium (LD) mapping were used to identify chromosomal regions involved in whitefly resistance. In an F2 population based on a cross between the whitefly susceptible cultivar 'Christmas Drumhead' and the resistant 'Rivera', we measured whitefly adult survival and oviposition rate as well as some morphological characteristics possibly involved in the resistance (time of head formation, leaf wax layer and leaf toughness). QTLs were found for the whitefly resistance parameters 'adult survival' and 'oviposition rate', explaining 14% and 13% of the variance, respectively. A strong QTL was found for 'wax layer', explaining 64% of the variance. None of the QTLs identified for the morphological traits co-localized with the QTLs for adult survival and oviposition rate. Therefore it is unlikely that these morphological traits contribute to the resistance observed. Although a strong resistance towards the cabbage whitefly was observed in the heading cabbage cultivar 'Rivera', no major QTL was detected for survival and oviposition rate. The resistance in this variety is probably based on the interaction of several genes or different resistance mechanisms. Further support for this came from the LD-mapping experiment in which we genotyped cabbage accessions using the 90k Axiom array that was developed within the project, and phenotyped them for 'adult survival' and 'oviposition rate'. Significant associations between these whitefly resistance related traits and markers were found on chromosomes 1, 2, 4, 5, 6, 7 and 9, showing that several chromosomal regions contribute to whitefly resistance observed in heading cabbage accessions. Markers linked to these QTLs are now available and may be used by breeding companies for indirect selection of genomic regions that contribute to whitefly resistance.

We also used a fully whitefly resistant plant of the brassica wild relative *B. incana*. This plant is densely covered with trichomes which may contribute to resistance. The resistant *B. incana* plant was crossed with a susceptible *B. oleracea* cultivar and the resulting F1 was backcrossed with the *B. incana* parent. In this cross we mapped whitefly resistance to a single locus explaining 57% of the variance for whitefly adult survival and 82% for oviposition rate. At the same locus we also mapped the presence/absence of trichomes. There was a strong correlation between the presence of trichomes and whitefly adult survival (-0.71) and oviposition rate (-0.89). The presence of the trichomes is likely responsible for the resistance observed. Again, information on markers co-segregating with the resistance is now available, thus facilitating resistance breeding.

In conclusion the PGR Secure project has identified novel sources of resistance against the cabbage whitefly and cabbage aphid in landrace accessions of *B. oleracea* var. *capitata* as well as in wild relatives of *B. oleracea.* This resistance is likely based on different mechanisms and markers linked to the genes involved in the resistance are now available to the brassica breeding community. The PGR Secure project also enriched the brassica community with a 90k Axiom array that will show its value for a range of applications. The phenomics and genomics approach used within the PGR Secure project may also serve as an example for other crops.

Predictive characterization

Conventionally, to identify desirable traits in germplasm collections, all the plant materials need to be grown out in field trials, characterized (i.e., finding the desired characters) and evaluated. This can be expensive and time-consuming. A better approach is to predict which accessions contain the desired traits using geographic and environmental data along with Geographic Information Systems (GIS) analysis. This so-called predictive characterization approach builds on the hypothesis that different environments exert divergent selective pressures on plant populations, increasing the probability of finding specific traits under certain circumstances (for example, we might expect to find traits of saline tolerance in plants growing in areas where salt levels are high) and represents a more cost-effective method.

One of the first systematic applications of using a predictive link between a specific resistance trait and a set of environmental parameters, named the Focused Identification of Germplasm Strategy (FIGS) used biotic and abiotic matching techniques. FIGS was developed at the International Centre for Agricultural Research in the Dry Areas (ICARDA) based on early work by Michael Mackay in the 1980s and 1990s. The first FIGS studies used a series of filters based on scientific expert knowledge for matching environmental profiles that were known to be suitable for adaptations leading to the target trait properties in landraces growing in such locations.

FIGS studies so far have mainly been applied to major crops, in particular wheat and barley, and recently also to faba bean. Building upon the foundation of the FIGS approach, further studies that use ecogeographical information or previously recorded characterization and evaluation (C&E) data have been developed and were tested for their applicability to CWR and LR within the context of the

PGR Secure project. These additional predictive characterization studies on CWR and LR material have explored the methods called ‘ecogeographical filtering’ and ‘calibration’ (Figure 4).

The ecogeographical filtering method combines the spatial distribution of the target taxon with an ecogeographical land characterization (ELC) map that characterizes the environments that are likely to impose selection pressure for the adaptive trait investigated, to identify accessions or populations that are likely to contain the trait of interest. In the predictive characterization context it uses a taxon-specific ELC map that is developed based on the variables most relevant for adaptation and for determining the species’ distribution. This map aims to represent the adaptive scenarios that are present over the territory studied.

As a first step in this method, the ecogeographical categories from the ELC map are assigned to each occurrence record according to its coordinates and the records are then grouped according to their ELC map category. After all georeferenced occurrences have been ecogeographically characterized, the second step is to select occurrences from each group that comply with specific environmental requirements related to the traits of interest: the specific ecogeographical variables (geophysical, edaphic or bioclimatic) that best describe and delimit the environmental profile likely to impose selection pressure for the adaptive trait of interest. These are then used for further filtering to obtain a final subset of occurrences.

The calibration method uses existing C&E data for the trait of interest, together with eco-geographical data specific to the environment at collecting sites from which these accessions were collected, to identify existing relationships between the trait and the environment. Based on these relationships, it calibrates a prediction model. This prediction model is then applied to other non-evaluated accessions to identify those that, according to this model, are likely to have a higher probability of genetic adaptation for a target trait property. The model therefore aims to identify a subset that is more likely to show the target trait property than a subset merely selected randomly. The calibration method can be used when availability of evaluation data is not a limiting factor. The use of the calibration method has been described in recent studies on morphological and agricultural traits in barley and wheat stem rust.

The traits that we identified—based on an expert consultation and literature reviews—as important for the four target genera of the PGR Secure project, as well as variables and thresholds that were used within the ecogeographical filtering method to identify and select the environments likely to favour the development of tolerance or resistance traits, are summarized in Table 1.

The ecogeographical filtering method was applied to CWR and LR of all four genera and eight sets of accessions were produced containing those that are expected to have a higher likelihood of containing genetic diversity for the selected adaptive traits. The application of the calibration method requires the availability of evaluation data for the respective genera. The evaluation data that we managed to compile from public sources, direct contacts with curators and through the PGR Secure consortium, both for LR and CWR, proved to be too few to be able to implement the method on these four genera. The R-scripts developed for that method have therefore been tested on a wheat dataset made available by one of the external experts that collaborated in the predictive characterization activities. Both methods have been documented in the document, ‘Predictive characterization of crop wild relatives and landraces. Technical guidelines version 1’ which will be published by Bioversity International and freely downloadable from the Bioversity website.

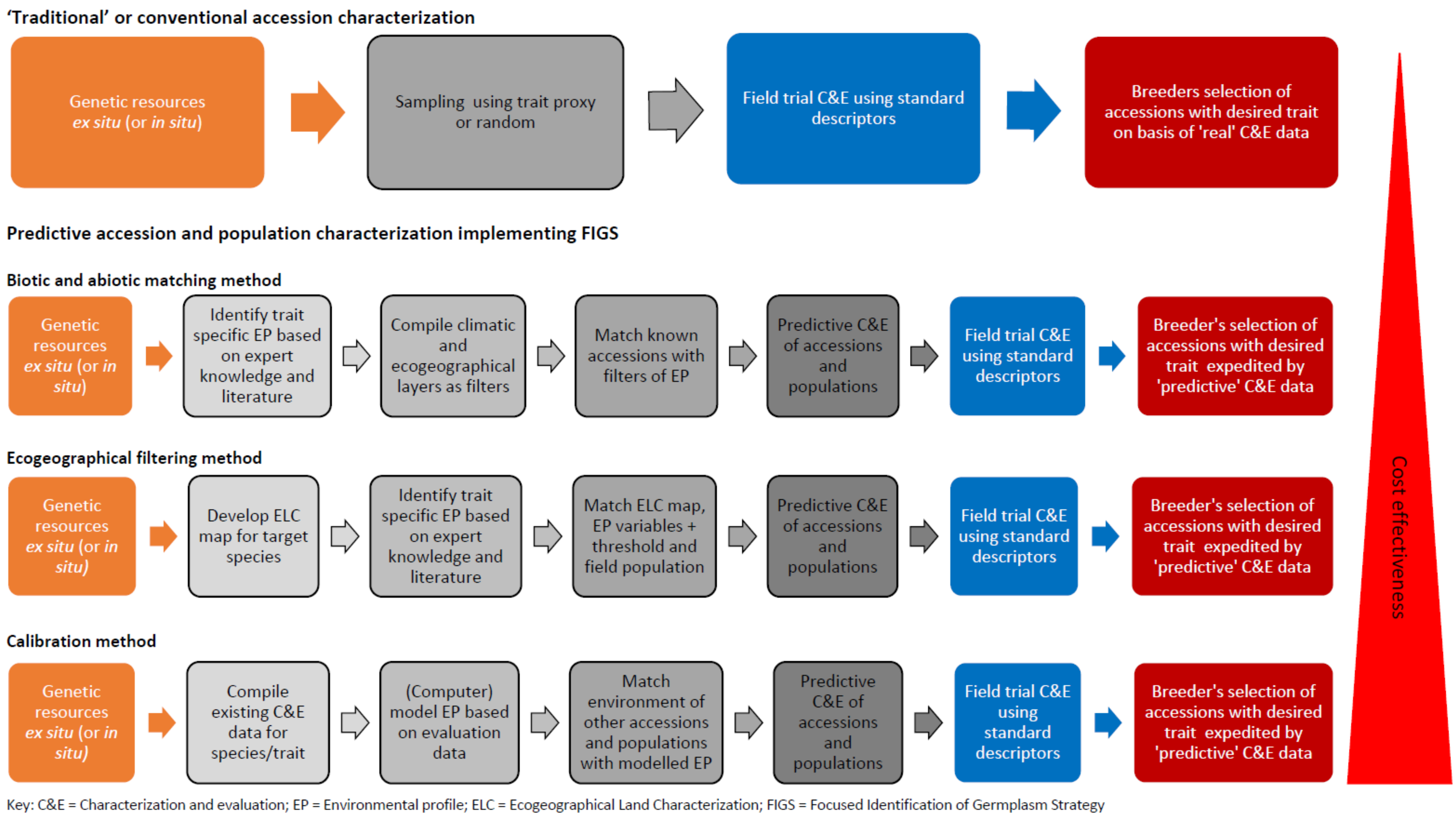

Figure 4. Schematic representation of approaches to predictive characterization

Table 1. Traits and variables for the project's target genera *Avena*, *Beta*, *Brassica* and *Medicago*

Genus	Identified abiotic trait	Identified variable(s)	Threshold value
Avena	Aluminium toxicity	Soil pH; Soil organic carbon content T_OC	< pH 5.5 < 1.2% T_OC
Beta	Drought	De Martonne aridity index (De Martonne, 1926), calculated based on temperature and precipitation of the three driest months (July, August and September in the Northern Hemisphere).	< 10
Brassica	Drought	De Martonne aridity index	< 10
	Salinity	Topsoil salinity (TSS) measured as electrical conductivity in dS/m (deciSiemens/metre)	> 4 dS/m Highest values in records with TSS > 4
		Mean temperature values for the driest months	
Medicago	Frost	BIOCLIM 11	< -2°C

Theme 2: Crop wild relative and landrace conservation

Actions undertaken under Theme 2 have resulted in the development of national and Europe-wide conservation strategies for high priority European CWR and LR resources. The research involved two components: a) CWR conservation and b) LR conservation.

CWR and LR conservation training

The joint PGR Secure/ECPGR[2] workshop, 'Conservation strategies for European crop wild relative and landrace diversity' (the Palanga workshop), was convened in Palanga, Lithuania from 7–9 September 2011 to discuss and agree a strategic approach to European and national CWR and LR conservation with the aim of ensuring the systematic conservation of European PGRFA which are important for food security and the European economy. The workshop addressed five primary topics: 1) production of National Inventories (NIs), 2) taxon prioritization, diversity and gap analysis, and threat assessment, 3) data collection, management and exchange, 4) linking conservation to use, 5) development and implementation of national CWR and LR conservation strategies by the ECPGR Network members. The workshop comprised a series of presentations and discussion sessions on the state of the art of CWR and LR conservation in Europe, available approaches and methods for their conservation, and discussion on their practical application. Participants shared knowledge on current national activities, discussed the practicalities of developing national CWR and LR conservation strategies, and agreed on the way forward. The workshop was attended by 101 participants from 38 European countries and one from the United States of America. Participants included members of the ECPGR *In Situ* and On-farm Conservation Network (Wild Species Conservation in Genetic Reserves and On-farm Conservation Working Groups) and Documentation and Information Network, as well as Consortium and External Advisory Board Members of the EU Framework 7 project, PGR Secure. A review of progress in national CWR and LR conservation in each European country is available via the online conservation Helpdesk (www.pgrsecure.org/helpdesk).

[2] European Cooperative Programme for Plant Genetic Resources

Conservation helpdesk

A CWR and LR conservation helpdesk has been active throughout the project in providing assistance to national programmes in the development of national CWR and LR conservation strategies through one to one contact by email and in-country visits, as well as by the provision of online resources (www.pgrsecure.org/helpdesk). Regular communication has also been maintained with all European national PGR programmes to offer support for the development of their national conservation strategies.

The online helpdesk includes an introductory page providing background information, and an explanation of the role of the helpdesk and how to use it. Links to two additional pages are provided which contain a range of resources to aid and inform the national CWR (www.pgrsecure.org/helpdesk_cwr) and LR (www.pgrsecure.org/helpdesk_lr) conservation strategy planning process, as well as links to email addresses for one-to-one support.

Crop wild relative conservation

European CWR inventory

The CWR Catalogue for Europe and the Mediterranean, which is a comprehensive list of CWR taxa in the region and their occurrences in geographical units (countries or sub-national units) related to cultivated plants of all types (including food, fodder, forage, industrial plants, ornamentals and medicinal plants) has been revised using the latest data provided by the Euro+Med PlantBase Secretariat. The Catalogue provides an overview of the breadth of crop and CWR diversity in the European region and the baseline data for conservation planning at regional scale. National CWR checklists were extracted from the original version of the Catalogue and provided to each European country for use in the national PGR programmes to form the basis of national checklists, inventories and subsequently, national CWR conservation strategies and action plans. The data were provided to the countries prior to the PGR Secure project and again at the Palanga workshop, as well as being made available via the online conservation helpdesk. The revised CWR Catalogue data are available via the PGR Diversity Gateway where they are searchable and from where national checklists can be generated to form the basis of national inventories and conservation strategies. A peer-reviewed publication describing the process of creating the CWR Catalogue is in preparation.

National CWR conservation strategies

Seven European countries have to date completed national CWR checklists and inventories: Cyprus, Czech Republic, Finland, Italy, Norway, Spain and the United Kingdom (UK). The data have been web-enabled via the PGR Diversity Gateway and the Italy and Spain CWR checklists and inventories are also available via the case study websites of those countries.

National CWR conservation strategies for the three project case study countries Finland, Italy and Spain, as well as for Cyprus, have been completed and published and significant progress has also been made in Albania, Bulgaria, the Czech Republic, Norway, Sweden and the UK. Each strategy follows a similar general model but has been adapted according to factors such as the number of native CWR present, the economic use of the related crops, and national conservation and utilization priorities.

European CWR conservation strategy: from conservation planning to conservation practice

Europe is an important centre of diversity of many crops and their wild relatives and these CWR are potential genetic resources for crop improvement. Europe's CWR diversity is therefore an important resource for the maintenance of food security and for safeguarding the substantial economic gains to Europe through crop production in the region. We have developed an integrated European CWR conservation strategy which combines national CWR conservation strategies and a regional CWR conservation strategy for priority taxa at European level (Figure 5). A list of priority CWR species native to Europe in more than 20 priority crop gene pools has been produced and ecogeographic data analysed to identify high priority populations for conservation action.

Recent advances in our understanding of CWR diversity in the region, as well as in planning for their complementary conservation, provides a solid foundation for the development of a strategic approach to their conservation in Europe based on a range of commonly agreed and widely tested scientific concepts and techniques. However, the perceived value and impact of the integrated CWR conservation strategy for Europe ultimately depends on successfully channelling conserved germplasm from *in situ* and *ex situ* conservation facilities to the user community for crop improvement. It is essential that the strategy meets the interests and needs of the stakeholder community (public and private plant breeding research institutes, breeding companies, plant genebanks, farmers and agro-NGOs). To this end, we have identified four key challenges to enhancing the utilization of conserved plant germplasm:

1. Strengthening the interface between *in situ* and *ex situ* conservation;
2. Increasing efforts to characterize and evaluate conserved germplasm;
3. Improving the availability of conservation, characterization and evaluation data to end users;
4. Addressing issues of access by the user community to *in situ* and *ex situ* conserved germplasm.

Achieving effective conservation and utilization of European CWR diversity will require a coherent, regionally coordinated policy and the appropriate resources to fund their conservation, characterization and evaluation. Therefore, to achieve sustainable conservation of CWR and maximize their sustainable exploitation in Europe, there is an imperative to develop an EU-led policy to harmonize their conservation, characterization and evaluation with existing biodiversity conservation and agricultural initiatives, and to develop new initiatives where necessary. The preparation and publication of 'A concept for *in situ* conservation of crop wild relatives in Europe' (www.pgrsecure.org/documents/Concept.pdf), which was led by members of the PGR Secure consortium, is a landmark in CWR conservation in Europe and will be utilized to lobby for the required action and European and national levels.

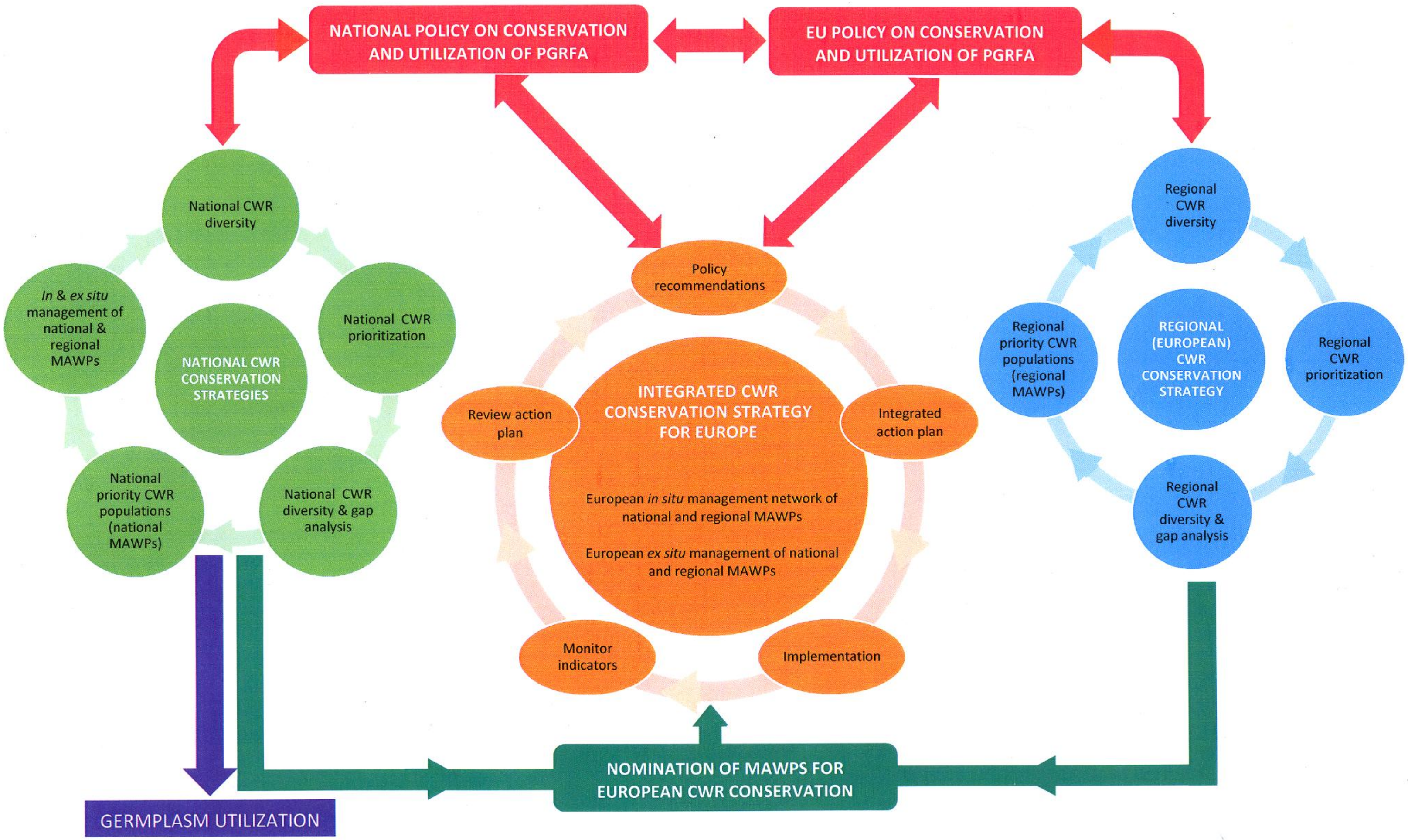

Figure 5. Schematic representation of the concept for *in situ* conservation of CWR in Europe[3]

[3] Kell, S., Maxted, N., Ford-Lloyd, B.V. *et al*. (in prep.) A methodological approach to complementary conservation of priority European CWR

Landrace conservation

A major step forward in LR conservation in Europe was the publication of a set of descriptors for collecting, recording and making available data for LR that are maintained *in situ* (on-farm). This set of descriptors will be adopted by the ECPGR and used to manage national LR inventories throughout Europe. Data standards and a tool for recording LR data have been developed and are available via the online conservation helpdesk, LR resources page (www.pgrsecure.org/helpdesk_lr) (Figure 6).

Figure 6. Data standards and a tool for recording LR data are available via the online conservation helpdesk: www.pgrsecure.org/helpdesk_lr

LR conservation strategies have been published for the project case study countries Italy and the UK at: www.pgrsecure.org/publications and the LR conservation strategy for Finland will be published in the MTT Agrifood Research Finland report series, as well as being available via a link from the PGR Secure website. Progress in the development of LR conservation strategies for three case study countries will inform a model for national LR conservation across Europe.

A European LR priority gene pool (*Avena*, *Beta*, *Brassica* and *Medicago*) strategy has also been published on the project website. The strategy highlights the lack of conservation actions for LR of target crops that are maintained *in situ* (on-farm) and the need to compile inventories as a basis for their implementation.

Finally, based on the above-mentioned strategies and other documents, a generic European LR conservation strategy has been published that focuses on both conservation and enhancement of use priority actions. The further priority conservation actions needed are:

1. Compile a comprehensive European LR inventory;
2. Collect and conserve germplasm samples of priority LR populations in *ex situ* collections;
3. Promote LR reintroduction from genebanks to on-farm sites;
4. Increase European coordination in developing and implementing measures for LR conservation;

5. Make available adequate funds for LR *in situ* (on-farm) and *ex situ* conservation actions and for carrying out research on LR diversity in the context of climate change and unpredictability.

In particular, the compilation of a European inventory of LR that are maintained *in situ* (on-farm) is seen as the principal means to carry out efficient and effective conservation. This is because such an inventory, when made public, ensures the possibility of:

- Collecting materials not already present in *ex situ* collections;
- Promoting the direct use of LR in agriculture (and in doing so achieving their *in situ* (on-farm) conservation);
- Promoting the use of LR in conventional and participatory plant breeding;
- Identifying research case studies useful to deepen knowledge on LR (within- and among- genetic diversity level, *in situ* genetic diversity evolution under changed climatic conditions, level of genetic diversity that can be maintained under different agro-ecosystems, different management systems, socio-economic factors that drive conservation);
- Identifying agrobiodiversity hot spots for conservation activities.

The compilation of a European LR inventory will also allow the assessment of overall progress on implementation and related follow-up processes of the GPA, facilitate cooperation among European countries, and will be a useful example to develop *in situ* conservation actions at global level.

In terms of LR use, the most important required actions are:

1. Promote the use of home garden LR in community and home gardens;
2. Register LR as ‘conservation varieties’ and award quality marks for typical, local products derived from LR;
3. Carry out campaigns aimed to promote local economies based on locally sourced products from LR;
4. Facilitate cooperation among the formal sector, farmer networks and farmer organizations;
5. Stimulate the use of LR in plant breeding programmes aimed at creating heterogeneous (i.e., genetically diverse) varieties suitable for environmentally friendly agronomic systems.

The European LR conservation strategy will have practical and policy implications beyond the lifetime of the PGR Secure project, although requiring further development and promotion by the relevant players, most notably the ECPGR On-farm Working Group.

Theme 3: Improved use of CWR and LR by breeders

Actions undertaken under Theme 3 have resulted in greater awareness amongst the plant breeding community of the breadth of genetic material available from CWR and LR and of the enhanced access to these resources for crop improvement, as well as improved communication between the conservation and end user communities.

Understanding and improving the PGR system in Europe

Understanding the needs of the European CWR and LR user community, including genebanks, public research institutes, commercial plant breeding companies, agro-NGOs (non-governmental organizations) and government, is fundamental to improve the links between conserved CWR and LR resources and their use in plant breeding programmes for crop improvement. To this end an elaborate study has been carried out to analyse PGR conservation and use in Europe to date. During the study, representatives of the five interest groups: genebanks, public research institutes, plant breeders, agro-NGOs, and governments, were interviewed. In total, 20 countries were visited and around 130 semi-structured interviews took place with the various PGR stakeholders concerned. An online survey was also conducted which was answered by 226 respondents.

The interim results of the study were discussed during the workshop, 'On the conservation and sustainable use of plant genetic resources in Europe: a stakeholder analysis' which was convened in Wageningen in November 2013 to discuss the constraints in the conservation and use of PGR in Europe. Eighty participants from 21 European countries attended, representing the five stakeholder groups (Figure 7). This was a landmark meeting as it was the first time that these diverse stakeholder groups had come together to discuss a common issue of concern to all groups.

Figure 7. Participants at the PGR Secure stakeholder workshop, 'On the conservation and sustainable use of plant genetic resources in Europe: a stakeholder analysis', Wageningen, November 2013

The results of the semi-structured interviews, the online questionnaire and input from the workshop were integrated into the final report 'On the sustainable use and conservation of plant genetic resources in Europe'. In this report a SWOT (strengths, weaknesses, opportunities and threats) analysis of these data is presented together with a vision of an ideal European PGR system (i.e., a system in which PGR are adequately conserved and easily available for utilization for crop improvement) and recommendations on how we can improve the current system and move towards this ideal system.

There are many notable strengths and competences within the PGR system in Europe today and also several promising opportunities coming from outside the system. Perhaps most importantly, there is today a general consensus that genetic resources are important and should be protected through conservation measures. In the same vein, member states have accepted the international legal obligations for conservation of PGRFA, which puts ethical pressure on policy- makers. Within the current system the conservation sector does conserve a substantial amount of genetic resources *ex situ*. There are also public funds available for conservation, evaluation, PGR research and pre-breeding and there is an interest among the stakeholders to cooperate within such projects. A large knowledge base and high competence, in combination with innovative thinking among the stakeholders, leads to successful projects and development of efficient new tools that can be used in conservation and breeding.

However, there are several major problems that need to be addressed if we are to secure reliable conservation of essential genetic resources and make it possible to use these resources efficiently in future efforts to assure food security. A central problem is that genetic resource issues often have a low priority, both at the European and national governmental levels, which leads to insufficient support of conservation activities and a lack of implementation of conservation and use policies. *Ex situ* conservation is the most well established conservation approach for PGRFA, but most of the European genebanks are still not independent units with regard to funding or programmes, and under-funding frequently puts genetic resources at risk. In addition, most genebanks do not follow defined standards to assure transparency and a minimum quality of the work. The visibility and access to the *ex situ* collections are often limited and there is a lack of relevant evaluation data available in the collection databases.

Another issue affecting several stakeholders is the prevalence of short-term funding and instabilities of policies. Both conservation and breeding are long-term efforts that demand long-term commitments. For example, pre-breeding projects are crucial to bridge the gap between genetic resources and conventional breeding, but they need funding over a long period of time to be successful.

A range of problems are also associated with on-farm and *in situ* conservation. At the heart of the problem is perhaps uncertainty regarding responsibility. At the governmental level, the responsibility for *in situ* conservation is often shared between authorities and the terms of cooperation and responsibility are not always clear. Genebanks have traditionally worked with *ex situ* conservation and have not risen to the challenge to take a leading role in development of *in situ* and on-farm conservation strategies. In many countries inventories of LR and CWR are still missing and so are conservation strategies targeted at these important genetic resources. Clarification over the national lead responsibility for implementing on-farm and *in situ* conservation would alleviate much of the inertia associated with active complementary conservation.

In this study we have identified a long list of weaknesses and threats. However, our main message is that these can be overcome, but actions are needed both on the national and European level. To this end we have put forward 12 recommendations for improving the European PGR system:

- Establish a European Plant Germplasm System;
- Establish a technical EU infrastructure for the organization of conservation of PGRFA measures;
- Establish a EU information infrastructure for conservation of PGRFA;
- Disentangle genebank tasks from plant breeding research and plant breeding tasks at the national level;
- Establish a legal basis for *in situ* and *ex situ* conservation of PGRFA in the EU;
- Carry out an inventory of financial means available to genebanks and estimation of financial means needed for a fully functioning European network of genebanks;
- Increase the visibility of genebanks on the internet;
- Clear uncertainties concerning access and benefit sharing (ABS) rules, so that breeding companies can take economic decisions on a safe legal basis;
- Strengthen research to better understand the amount and geographic distribution of genetic diversity present in priority crop gene pools;
- Develop a European infrastructure for long-term crop specific pre-breeding programmes;
- Strengthen the European agro-NGOs sector;
- Establish a European Network of Private-Public-Partnership programmes for evaluation of PGR in Europe.

At the centre of the recommendations is the development of a legal and infrastructure framework for the conservation of PGR in Europe. The final report, its annexes and a policy paper based on this report can be downloaded from www.nordgen.org/index.php/en/Plants/Innehaall/WorkshopsConferences/Plant-Genetic-Resource-Workshop-2013/Final-report.

A draft of the policy paper was sent to members of the Executive Committee of the ECPGR with a request for comments and feedback. The final downloadable version will be sent to the ECPGR Secretariat and to the European Commission Directorate-General for Agriculture and Rural Development, Directorate E.4, 'Evaluation and studies' (under Directorate E, 'Economic analysis, perspectives and evaluation; communication'). The policy paper is an important input for the 'Preparatory action on EU plant and animal genetic resources agriculture' (www.geneticresources.eu) and will also be announced by a short communication in Agra-Europe (www.agra-europe.de) to reach a wider public.

Facilitating greater communication within the European PGR system

To facilitate European PGR stakeholders to establish contacts, which in turn will promote the use of CWR and LR through improved cooperation, two approaches were used. First, a web-based map of PGR stakeholders in Europe was established. The web-application PGR-COMNET (www.pgrsecure.org/pgr-comnet) currently visualizes more than 460 stakeholders on a map. Secondly, a stakeholder market day was organized at the stakeholder workshop in Wageningen with the aim of establishing new or renewed partnerships and potential future cooperation among the participants. After the sessions, the participants gave feedback on the stakeholder market day by providing information on their partnerships or potential cooperation established. The replies were categorized into six clusters of interests: 1) *ex situ* conservation (eight consortia, each representing two to five partners); 2) *in situ* conservation (two consortia, each representing two to four partners); 3) on-farm management (three consortia, each representing three to four partners); 4) characterization and evaluation (five consortia, each representing two to three partners); 5) pre-breeding (five consortia, each representing two to four partners); and 6) knowledge transfer (five consortia, each representing two to five partners). The clusters were further analysed according to the specific subjects, methods and species the partners are interested in. About three months after the workshop, the stakeholder market day participants were asked to give further feedback on the status of their partnerships. Out of 26 partnerships proposed, replies from 13 consortia were collected. There was generally positive feedback on the stakeholder market, and many respondents stated that they had been able to establish contacts with colleagues through this event. Since then, most respondents have been in contact with their partners or will soon meet at upcoming workshops or conferences. Some of the respondents are already planning future collaborations like the preparation of joint Horizon 2020 project proposals.

Channelling potential interesting germplasm into breeding programmes
Online databases were screened for agronomically interesting accessions of *Avena* and *Beta* species and the results were circulated to private breeding companies and public research institutes. Further, information on germplasm resistant to cabbage aphid and molecular markers for whitefly resistance identified under Theme 1, 'phenomics and genomics' was sent to European companies involved in brassica crop improvement. Responses have been received to both communications from a number of breeders interested in obtaining further information and material.

Theme 4: Informatics
Actions undertaken under Theme 4 have resulted in the availability of a resource base for access to CWR and LR conservation and trait data for use by the full range of stakeholders—the Plant Genetic Resources Diversity Gateway (PGR Diversity Gateway).

What is the Plant Genetic Resources Diversity Gateway?
The PGR Diversity Gateway (http://pgrdiversity.bioversityinternational.org) is an online information system that provides the PGR community—including breeders, conservation scientists and protected area managers—with information on CWR and LR diversity and the capacity to upload their own data. The PGR Diversity Gateway is public and provides free access to:

- A portal and visualization map service;
- A means to maintain, access and share germplasm conservation and use data;
- An advanced communication and information tool to facilitate country reporting and policy decision-making on PGRFA;
- An infrastructure for storing and linking CWR and LR conservation, characterization and trait data;
- A central point for linking national, regional and global CWR and LR information.

Data have been uploaded to the system, both from the project (CWR and LR checklists and inventories, national and regional CWR and LR conservation strategies, trait data for *Avena*, *Brassica*, *Beta* and *Medicago*) and from other existing sources (e.g., EURISCO, USDA). The data already in the system include:

- 531,982 plant germplasm accession records;
- CWR checklists containing 14,860 taxon records;
- CWR inventories containing 4,791 taxon records;
- Forest gene conservation units comprising 3,110 taxon records;
- Organizations (contact details/location map): 20,644 records.

Various adaptive trait data records have been uploaded to the system. For all records that have coordinates (830,452 records), data for 19 climatic variables, soil types, human footprints and land cover can be extracted from available services. The data inferred enables identification and characterization of landscapes where material was either collected or a population exists. The Gateway also has a map service that displays every record that has geo-coordinates. Records are displayed in group by proximity including the additional inferred environmental information on the observation or point. The system has the functionality to download the data searched.

The PGR Diversity Gateway has a simple platform architecture and includes three different entry points—trait information, CWR inventories and LR inventories—allowing users to choose their entry point to the information they require, while maintaining the capacity to link to existing online sources of information. The data that they can access via the system includes national inventories, national crop and CWR checklists, national and European conservation strategies, adaptive trait summary data linking to other data resources, *ex situ* and *in situ* conservation data, mapping services and environmental layers. Not all users are technically minded, so a simple interface is provided. In addition, since the incoming data are constantly increasing and new sources and domains are impossible to predict in advance, the system has the power to expand in a flexible way.

What is the design behind the PGR Diversity Gateway?

The PGR Diversity Gateway is designed using an ontology approach. An ontology is a description of the concepts and relationships that can exist for a community. Rather than relating concepts to each other through the structure of the database, an ontology relates concepts through their associated metadata. This allows great flexibility and potentially infinite growth. For example, if the user would like to access data by region but only country data are available, by using an ontology it is simple to search the database through regions without the concept of 'regions' being directly related to the data.

In order to accommodate this flexibility and manage large quantities of data, we decided to move away from a traditional relational model to embrace new technologies and workflows. The system is implemented by using two main kinds of databases: the *document* database and the *graph* database (*MongoDB* and *Neo4j* respectively). The combination of these two data storage engine types allows us to handle very large quantities of data with dynamic structures, providing extremely fast response times both for the data and the metadata and implementing inference algorithms to make the system a very powerful portal.

The ontology component was developed using internationally agreed standards, some of which were developed during the project phase and thus are community-agreed standards with templates. The system is capable of producing and retrieving useful information, storing and retrieving many diverse data types and discovering relations between them. It includes over 17,000 defined concepts. The standards ensure that the most important information is collected and that data are provided in a common format allowing for interoperability between datasets. Examples of standards used are:

- FAO/IPGRI Multi-Crop Passport Descriptors (MCPD) used generically for genebank information and documentation;
- Descriptors for Web-Enabled National *In Situ* Landrace Inventories for on-farm conservation data;
- Standard for National Checklists, National Inventories and Conservation Strategies, v1 for national CWR checklists, inventories and conservation strategies;
- Standards for adaptive trait description.

In addition, linked to these the system ontology uses over 30 other standards: Agrobiodiversity household assessments; EEC CORINE Land Cover (CLC) nomenclature; EEC EUNIS habitat type nomenclature; FAO Land use 1990; FAO/WIEWS Institutes; Forest genetic resources (FGR) inventories in Europe (EUFGIS); Global Environment Stratification (GENS); Global land cover type (ESA-GlobCover 2009 project); FAO Harmonized world soil database 2009; Human Foot Print; ISO 15924-alpha4; ISO 15924-numeric; ISO 3166-1; ISO 3166-2; ISO 3166-3; ISO 4217-A; ISO 4217-H; ISO 639-1; ISO 639-2; ISO 639-2B; ISO 639-2T; ISO 639-3; ISO 639-5; IUCN category; IUCN conservation; IUCN criteria; IUCN habitat; IUCN habitat score; IUCN threat; MCPD; NatureServe threat; World Bank Institute (WBI) income classification; World Bank Institute (WBI) lending classification; WORLDCLIM.

If geo-coordinates are available, these standards and services extract environmental (bioclimatic variables), soil type, land cover and human footprint information that is added to the dataset and can be seen when searched. The datasets are automatically enriched by the system and these additional data not only increase the dataset quality and quantity but also provide users with detailed information on the environmental characteristics (environmental profiles) for the sample(s) or observation(s) being looked at.

4.1.4 Potential impacts of the PGR Secure action

Socio-economic impact and wider societal implications of the action

The potential impacts of the project action are: a) better access to and wider take-up of conserved CWR and LR resources in plant breeding programmes; b) increased capacity and options for crop improvement to support European farming and to back-stop food security; c) systematic national level action on conservation of European CWR and LR resources; and d) improved knowledge to inform coherent planning of plant breeding and agrobiodiversity conservation policy in Europe—all of which will ultimately result in greater European food security. Tables 2–7 detail the specific potential scientific, technological, economic, competitive and social impacts of the project under each of its four themes.

The project results will benefit a range of stakeholders including: a) small and large plant breeding companies; b) scientists and policy-makers in public and private research institutes; c) farmers and others working in the agricultural sector; d) genebank and protected area managers, and the broader conservation community; e) government agencies and NGOs involved in plant conservation, plant breeding and national or local nutrition and food supply issues; f) the European Commission; and ultimately g) the European farm product consumer. However, it is the improved use of CWR and LR by plant breeders and farmers that will have the greatest economic and social impact in Europe. A critical issue currently hindering the wider use of these resources was highlighted in FAO's Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture (www.fao.org/agriculture/crops/core-themes/theme/seeds-pgr/sow/sow2/en/) which stated that: "Considerable opportunities exist for strengthening cooperation among those involved in the conservation and sustainable use of Plant Genetic Resources for Food and Agriculture (PGRFA), at all stages of the seed and food chain. Stronger links are needed, especially between plant breeders and those involved in the seed system, as well as between the public and private sectors". Recognizing that the success of the initiative hinges on bridging the gap between the conservation and use communities, the PGR Secure project sought to strengthen these links and therefore involved collaboration between European policy, conservation and breeding sectors throughout Europe.

Exploitation of project results: breaking through the scientific and industrial state of the art

The results of the action outlined in section 4.1.3 are major breakthroughs in the scientific and industrial state of the art of conservation and utilization of PGRFA in Europe. Specifically:

1. Under Theme 1, the accessions that have been found to be resistant to whitefly and/or aphids will undoubtedly be further investigated by breeding companies in order to develop resistant varieties. The same will apply to markers linked to resistance genes. The development of new predictive characterization models has great potential for improved targeting of CWR and LR populations for molecular characterization, thus reducing the number of populations that need to be analysed.

2. Under Theme 2a, the Consortium has implemented and enhanced concepts and methodologies initiated and published in the context of earlier EU-funded projects. The results and products of the action will fundamentally change the state of the art of CWR conservation in Europe because for the first time, a Europe-wide conservation strategy for a selection of high priority crop gene pools and national CWR conservation strategies for four countries (Cyprus, Finland, Italy and Spain) have been published. The practical implementation of the conservation strategies will provide greater security in terms of maintaining potentially useful germplasm, as well as the baseline knowledge required for its characterization and to make this information freely and easily available. Improved systematic CWR conservation will increase options for the use of germplasm in crop improvement programmes, leading to enhanced food security in Europe.

   Under Theme 2b, the Consortium has developed concepts and methodologies that were never applied before in a continental context. Therefore, the results and products of the action will fundamentally change the scientific state of the art of LR conservation in Europe and elsewhere.

The tools generated in the project (i.e., the 'Descriptors for Web-Enabled National *In Situ* Landrace Inventories' and the related database for LR *in situ* data recording) will significantly improve cooperation in *in situ* conservation activities at European level. For the first time, Europe-wide and national LR conservation strategies for at least three countries (Finland, Italy and the UK) have been published. The practical implementation of the conservation strategies will provide greater security of maintaining useful LR populations, as well as the baseline knowledge required for their characterization, wider use and *in situ* conservation actions at local level. In addition, to make LR related information freely and easily available will enhance options for the use of LR in agriculture and in crop improvement programmes. All the above-mentioned points not only strengthen the relationships between European countries, but potentially have positive fallout on the entire world conservation community.

3. The main result of research undertaken under Theme 3 is a policy paper that addresses the limitations of the European PGRFA conservation and use context, and how the limitations might best be overcome to enhance European crop production competition and improve food and nutritional security. If the results and recommendations of this paper are used by decision-makers at all policy levels within the EU to organize a comprehensive, efficient and effective common programme for the conservation and use of PGR, as well as for the establishment of the durable infrastructures required for the long-term operation of such a programme, a framework for science will come into existence allowing the much better exploitation of genetic resources for the benefit of all European citizens.

4. Sharing information on CWR and LR (Theme 4) has the potential to influence the way breeders conduct their activities. In addition, the free and wide accessibility of the information in a portal can stimulate more research in the area of genetic diversity (CWR and LR) to adapt to biotic and abiotic stresses caused by climate change.

Dissemination activities

Dissemination activities and the project products user communities are detailed in Tables 2–7 under each of the four project themes. A summary of the project dissemination activities is provided below.

Project website

The project website (www.pgrsecure.org) provides a general introduction to the project, its component work packages, a list of project collaborators and partner contact details, and a number of specific pages for disseminating the project results. Dissemination is primarily via the publications (www.pgrsecure.bham.ac.uk/publications) and conservation helpdesk (www.pgrsecure.bham.ac.uk/helpdesk) pages (project newsletters and factsheets, CWR and LR conservation strategies, project reports and other products arising from the work packages); a page hosted by NordGen dedicated to the stakeholder workshop and products associated with Theme 3, 'Improved use of CWR and LR by breeders' (www.nordgen.org/index.php/en/content/view/full/2481/); PGR-COMNET (www.pgrsecure.org/pgr-comnet – hosted by JKI and embedded in the PGR Secure website); pages dedicated to providing access to presentations given at, and the report of the CWR and LR conservation training workshop, 'Conservation strategies for European crop wild relative and landrace diversity' (www.pgrsecure.bham.ac.uk/palanga_workshop); and pages dedicated to dissemination of information about the project's final dissemination conference (www.pgrsecure.bham.ac.uk/conference), including access to the conference book of abstracts, programme and oral presentations (note, registration, abstract submission and logistical information now disabled).

Final dissemination conference

The project's final dissemination conference, 'ENHANCED GENEPOOL UTILIZATION: capturing wild relative and landrace diversity for crop improvement' (www.pgrsecure.bham.ac.uk/conference) was attended by 140 participants from 42 countries, of which half were from outside Europe, making it a truly international conference. The conference comprised twelve sessions organized within four themes:

- **Characterization techniques**: 'omics' techniques and predictive tools to identify traits and expedite plant breeding;
- **Conservation strategies**: national, regional and global CWR and LR conservation strategy development; targeted conservation to meet the needs of the plant breeding community; integration of CWR and LR diversity into existing biodiversity conservation programmes;
- **Facilitating CWR and LR use**: pre-breeding; meeting breeders' needs; integrating the conservation and user communities; policy enhancement;
- **Informatics development**: characterization, trait and conservation data management and accessibility; inter-information system operability.

Fifty-nine oral presentations and 56 posters were shared under these themes. The full conference programme and book of abstracts are available online and a summary of the conference will be published in *Crop wild relative* Issue 10 in November 2014 (www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_10.pdf).

Publications

Conference proceedings

A text based on the final dissemination conference but with additional invited authors will be published by CAB International (CABI) early in 2015 under the title 'Enhancing Crop Genepool Utilization: Capturing Wild Relative and Landrace Diversity for Crop Improvement'. Edited by Dr. Nigel Maxted (PGR Secure Project Coordinator) and Prof. Brian Ford-Lloyd (UoB), and Dr. Ehsan Dulloo (BIOVER), the contents of the book will be broadly synonymous with the conference themes. The text has a global market and is primarily targeted at agrobiodiversity conservation and use professionals, postgraduate students and public bodies.

Peer-reviewed publications

Four peer-reviewed publications arising directly from the project research have been published and a number of others are in press and in preparation (see section 4.2).

Project newsletters and factsheet

Two issues of *Crop wild relative* and its sister newsletter *Landraces* have been published and one further issue of each newsletter will be published before the end of 2014 (see www.pgrsecure.bham.ac.uk/publications). A project factsheet (www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/PGR_Secure_factsheet_opt imized.pdf) targeted towards different audiences (plant breeders, agrobiodiversity conservationists, policymakers and the general public) was published in seven languages and is available from the project home and publications pages.

Other publications

A range of other publications arising from the project are available for download from the project website or via links to pages hosted by partner institutions. These include: CWR and LR checklists, inventories and conservation strategies; project reports and other publically available deliverables; other products arising from the work packages such as the LR descriptors and tool for recording *in situ* LR data and final report and policy paper 'On the sustainable use and conservation of plant genetic resources in Europe' associated with Theme 3, 'Improved use of CWR and LR by breeders'; presentations given at the CWR and LR conservation training workshop and final dissemination conference; and the conference book of abstracts. Two PhD theses related to Themes 1a (phenomics and genomics) and 3a (CWR conservation) by students of the coordinating institute, the University of Birmingham, are approaching completion.

Dissemination at associated conferences, workshops and meetings

The project partners have taken every opportunity to disseminate the project results at relevant conferences, workshops and meetings other than those organized in the context of the project. A list of oral and poster presentations given at these events is provided in section 4.2.

Other dissemination activities

Project news and events have regularly been circulated by email, discussion fora, blogs, Facebook and Twitter. Public posters, TV and radio were used by MTT Agrifood Research Finland to disseminate news about the project research on LR conservation and to gather information from farmers and other LR maintainers. An infographic on the importance of CWR has been produced by Bioversity International and published on their website (http://visual.ly/importance-crop-wild-relatives).

Sustainability of project results

Sustainability of the results is critical to the success of the project. Thus, the project was initiated by and involves members of the existing ECPGR *In Situ* and On-farm Conservation Network (www.ecpgr.cgiar.org/networks/in_situ_and_on_farm.html) from 39 European countries who will be actively involved in planning, promoting and implementing national CWR and LR conservation strategies post-PGR Secure. Further, the Consortium itself included members of plant breeding and conservation research institutes, a SME specializing in the field of molecular genetics and applied genomics, as well as Europe's primary plant breeding research network, the European Association for Research in Plant Breeding (EUCARPIA), all of which have an interest in utilizing and taking forward the project results to benefit the wider conservation and use communities. In turn, and to further improve the dissemination and uptake of the results, the Consortium was supported by an External Advisory Board which involved senior researchers in plant breeding and PGRFA conservation and policy, as well as a Breeders' Committee comprising plant breeders and pre-breeders of major European food crops.

Table 2. Potential impacts of the PGR Secure action – Theme 1a: Novel characterization techniques – phenomics and genomics

IMPACT CATEGORY	PROJECT PRODUCTS AND POTENTIAL IMPACTS				
	Phenotyping data	**Transcriptomics data**	**Sequencing data**	**Molecular markers**	**Metabolomics data**
Scientific	Insight into morphological traits that may be causal to resistance	• Insight into genes that may be causal to resistance • Insight into resistance mechanism	• Insight into variation in gene content • SNPs	• QTLs for resistance • Insight into resistance mechanism	• Insight into role of metabolites in resistance • Insight into resistance mechanism
Technological	Evaluation techniques	–	Axiom SNP array	–	–
Economic	Basis for new varieties	–	More efficient breeding	Basis for new varieties	–
Competitive	Faster breeding	–	–	Faster breeding	–
Social	Less pesticides	–	–	Less pesticides	–
Means of dissemination	Scientific paper, PGR Diversity Gateway	Scientific paper, NCBI database	Scientific paper, NCBI database	Scientific paper, PGR Diversity Gateway	Scientific paper
User community(ies)	Genebanks, breeders, scientists	Scientists	Scientists/breeders	Scientists, breeders	Scientists

Table 3. Potential impacts of the PGR Secure action – Theme 1b: Novel characterization techniques – predictive characterization

IMPACT CATEGORY	PROJECT PRODUCTS AND POTENTIAL IMPACTS
	Technical guidelines for predictive characterization of CWR and LR
Scientific	• First guidelines for predictive characterization of CWR and LR using different methodological approaches implementing FIGS • Provides knowledge for targeted selection of CWR and LR accessions and populations for breeding
Technological	Provides a powerful methodology for predictive characterization and thus for the use of target CWR
Economic	More efficient selection of accessions with potential traits of interest for breeding programmes, leading to an economic advantage for the European plant breeding and farming industries
Competitive	More rapid selection of potential traits of interest for breeding programmes than with traditional screening methods
Social	Increased options for crop improvement through enhanced selection of breeding material; greater climate change resilience, food security and enhanced choice
Means of dissemination	Via the Bioversity and PGR Secure project website and a peer-reviewed publication
User community(ies)	• National PGR programmes • Plant genebanks • Breeders

Table 4. Potential impacts of the PGR Secure action – Theme 2a: Crop wild relative conservation

IMPACT CATEGORY	PROJECT PRODUCTS AND POTENTIAL IMPACTS			
	European crops and CWR inventory	**CWR National Inventories (NIs)**	**National CWR conservation strategies**	**European CWR conservation strategy**
Scientific	• Enhanced comprehensive inventory of European crop and CWR taxa • Published methodology for creation of the inventory to act as a model for use in other regions of the world	• First CWR NIs for most European (and non-European) countries • Provides baseline data for CWR conservation planning at national level • Model that can be used in other countries	• First national CWR conservation strategies for most European (and non-European) countries • Provides the knowledge needed for conservation action at national level • Model that can be used in other countries	• First comprehensive regional conservation strategy for high priority CWR • Provides the knowledge needed for conservation action at regional level • Model that can be used in other regions of the world
Technological	Provides: • The nomenclatural anchor onto which conservation and use data are attached • A baseline for future conservation prioritization, threat and utilization assessment at European level • Baseline national CWR checklists for each European country	Provide a baseline for future conservation prioritization, threat and utilization assessment at national level	Provide the strategic planning and scientific baseline data required for practical implementation of complementary conservation of national CWR diversity	Provides the strategic planning and scientific baseline data required for practical implementation of complementary conservation of European CWR diversity
Economic	Improved accessibility to baseline data required for European and national conservation planning	Improved accessibility to baseline data required for national conservation planning	Better focusing of conservation action leading to improved knowledge of CWR diversity for eventual exploitation in crop improvement programmes	
Competitive	This will be the only fully comprehensive regional crop and CWR inventory available; therefore, its existence gives Europe a clear competitive advantage over other regions and non-European countries	Better access to potential exploitation materials than competitor countries such as the USA, Canada, Australia, Russia, Brazil, India and China		
Social	Baseline knowledge of European CWR taxonomic diversity required for conservation and utilization leading to increased options for crop improvement	• Conservation of European CWR diversity leading to increased utilization options for crop improvement • Greater climate change resilience, food security and enhanced choice		

Table 4 cont'd. Potential impacts of the PGR Secure action – Theme 2a: Crop wild relative conservation

IMPACT CATEGORY	PROJECT PRODUCTS AND POTENTIAL IMPACTS			
	European crops and CWR inventory	**CWR National Inventories (NIs)**	**National CWR conservation strategies**	**European CWR conservation strategy**
Means of dissemination	Web-enabled (via the PGR Diversity Gateway)		• Partially web-enabled via the PGR Diversity Gateway • Reports for use by national PGR programmes, the European Commission and other stakeholders (see list of user communities below) • Peer-reviewed publications	
User community(ies)	• National PGR programmes • Government agencies and NGOs involved in plant conservation • Plant gene banks • Protected area managers • Plant breeding companies • Scientists and policy-makers in public and private research institutes • The European Commission			

Table 5. Potential impacts of the PGR Secure action – Theme 2b: Landrace conservation

IMPACT CATEGORY	PROJECT PRODUCTS AND POTENTIAL IMPACTS			
	European LR inventory	**National LR Inventories (NIs)**	**National LR conservation strategies**	**European LR conservation strategies**
Scientific	• Descriptors for *in situ* LR data recording (onto which conservation and use data are attached) and the tool for their recording were created that allow the compilation of the European inventory and act as a model for use in other regions of the world	• First LR NIs for three exemplar European countries • Provide baseline data for LR conservation planning at national level • Provide models that can be used in other countries	• First national LR conservation strategies for three exemplar European countries • Provide the knowledge needed for conservation action at national level • Provide models that can be used in other countries	• First comprehensive regional conservation strategies for general LR and for LR of high priority species • Provide the knowledge needed for conservation action at regional level • Model that can be used in other regions of the world

Table 5 cont'd. Potential impacts of the PGR Secure action – Theme 2b: Landrace conservation

IMPACT CATEGORY	PROJECT PRODUCTS AND POTENTIAL IMPACTS			
	European LR inventory	**National LR Inventories (NIs)**	**National LR conservation strategies**	**European LR conservation strategies**
Technological	• The Descriptors for *in situ* LR data recording (onto which conservation and use data are attached) and the tool for their recording provide a baseline for creating national LR checklists in each European country	Provide a baseline for future conservation prioritization, threat and utilization assessment at national level	Provide the strategic planning and scientific baseline data required for practical implementation of complementary conservation of national LR diversity	Provide the strategic planning and scientific baseline data required for practical implementation of complementary conservation of European LR diversity
Economic	Improved accessibility to baseline data required for European and national conservation planning	Improved accessibility to baseline data required for national conservation planning	Better focusing of conservation action leading to improved knowledge of LR diversity for eventual exploitation in crop improvement programmes and for direct use in agriculture	
Competitive	Descriptors for *in situ* LR data recording (onto which conservation and use data are attached) and a tool for their recording were created for the first time which gives Europe a clear competitive advantage over other regions and non-European countries	Better access to materials of potential use than competitor countries such as the USA, Canada, Australia, Russia, Brazil, India and China		
Social	Baseline knowledge of European LR diversity required for conservation and utilization (i.e., leading to increased options for crop improvement based on LR and direct use of LR in agriculture)	• Conservation of European LR diversity leading to increased utilization options for crop improvement • Greater climate change resilience, food security and enhanced choice		

Table 5 cont'd. Potential impacts of the PGR Secure action – Theme 2b: Landrace conservation

IMPACT CATEGORY	PROJECT PRODUCTS AND POTENTIAL IMPACTS			
	European LR inventory	**National LR Inventories (NIs)**	**National LR conservation strategies**	**European LR conservation strategies**
Means of dissemination	• Descriptors and the related data recording tool are both available for download from the PGR Secure website for use by national PGR programmes, the European Commission and other stakeholders (see list of user communities below)	• Web-enabled for Italy via http://vnr.unipg.it/PGRSecure/ • CD distribution to relevant governmental and regional agencies of Italy • Reports for use by national PGR programmes, the European Commission and other stakeholders	• National strategies available from the PGR Secure website (Italy, UK) and from https://portal.mtt.fi/portal/page/portal/mtt_en/mtt/publications (Finland) • European conservation strategies available from PGR Secure website • Related peer-reviewed and other publications • Conference presentations and posters	
User community(ies)	• National PGR programmes • Government and Regional agencies involved in LR diversity conservation • Farmers and farmer associations involved in LR diversity conservation • Plant gene banks • Protected area managers • Plant breeding companies • Scientists and policy-makers in public and private research institutes • The European Commission			

Table 6. Potential impacts of the PGR Secure action – Theme 3: Improved use of CWR and LR by breeders

IMPACT CATEGORY	PROJECT PRODUCTS AND POTENTIAL IMPACTS							
	Report on identification and discussions with stakeholders	**Transfer of selected material and associated knowledge to breeding companies**	**List and seeds of interesting accessions for breeding companies**	**Preliminary SWOT**	**Publication on trends in CWR/LR use in breeding**	**Web-based map of stakeholders**	**List of new partnerships**	**Transfer of linked markers to pests information to breeders**
Scientific	This interim report provides data on the constraints of PGR conservation and use in the EU	–	–	This interim report will provide more detailed data on PGR conservation and use constraints in the EU	This report will give an up-to-date detailed overview of the constraints of PGR use in the EU and provide action points to overcome these problems	This map will provide one of the first geographical overviews of PGR stakeholders in the EU	–	–
Technological	–	–	Provides an overview of *Avena*/*Beta* material of possible interest for breeders	–	Report provides a baseline for future research/activitie s	Provides an easy to handle web-based overview of EU PGR stakeholders	–	Use of linked markers improves the speed and efficiency in the development of new cultivars
Economic	–	Higher turnover through improved varieties	Users can benefit from this knowledge in their breeding programmes	–	Better exploitation of PGR from *ex situ* collections	Better exploitation of cooperation	Better exploitation of resources through cooperation	Use of pest resistance markers shortens the time to market entrance of a cultivar

Table 6 cont'd. Potential impacts of the PGR Secure action – Theme 3: Improved use of CWR and LR by breeders

IMPACT CATEGORY	PROJECT PRODUCTS AND POTENTIAL IMPACTS							
	Report on identification and discussions with stakeholders	**Transfer of selected material and associated knowledge to breeding companies**	**List and seeds of interesting accessions for breeding companies**	**Preliminary SWOT**	**Publication on trends in CWR/LR use in breeding**	**Web-based map of stakeholders**	**List of new partnerships**	**Transfer of linked markers to pests information to breeders**
Competitive	–	Better competitive position of breeding companies with headquarters in the EU	Being first on the market with improved cultivars can be profitable	–	Improved PGR use will lead to competitive advantage	Cooperation might bring competitive advantage to the partners concerned	Cooperation might bring competitive advantage to the partners	Being first on the market with improved cultivars can be profitable
Social	Promoting cooperation between PGR stakeholders within and between EU countries	–	–	–	Will contribute to improved food security	–	–	–
Means of dissemination	Via PGR Secure website and via the national consultants involved in WP5	Via identification of users; material and knowledge is sent to users	Via sending reports to stakeholders concerned; discussions during meetings with breeders	Via PGR Secure website and sending the report to specific stakeholders	Publication in scientific and popular context	Via internet and via sending reports to stakeholders	Via internet	Via identification of users. Material and knowledge is sent to users
User community(ies)	Government, genebanks, agro-NGOs, breeders, research institutes	Breeders, research institutes, agro-NGOs	Breeders, agro-NGOs and research institutes	Government, genebanks, agro-NGOs, breeders, research institutes	Government, genebanks, agro-NGOs, breeders, research institutes	Government, genebanks, agro-NGOs, breeders, research institutes	Government, genebanks, agro-NGOs, breeders, research institutes	Breeders, research institutes, agro-NGOs

Table 7. Potential impacts of the PGR Secure action – Theme 4: Informatics

<table>
<tr><th>IMPACT CATEGORY</th><th>PRODUCTS AND POTENTIAL IMPACTS</th></tr>
<tr><td></td><td>Plant Genetic Resources Diversity Gateway</td></tr>
<tr><td>Scientific</td><td>This development is an outreach product resulting from research on CWR and LR conservation and use</td></tr>
<tr><td>Technological</td><td>• The technology being used is not a closed database but can be changed when new data are made available by using a non-structured database and making use of ontologies in the backbone making it more robust and easy to bring together the various data types (traits, organizations, geo-referencing, threat status, conservation status, environment, taxonomy) and different domains (in situ /ex situ, conservation strategies, inventories)
• The ‘Descriptors and templates for data management and monitoring of CWR conservation and utilization for checklists, inventories and conservation strategies (v1)’
• ‘Descriptors and template for Web-Enabled Quantitative Trait Locus (QTL) Data, v1’
• Download of information is available to promote wider scientific use</td></tr>
<tr><td>Economic</td><td>Better access to traits that are important to breeders can improve the whole breeding process with clear economic benefits for the EU</td></tr>
<tr><td>Competitive</td><td>This will be the first web portal dedicated to providing open access to information on European CWR, LR and traits, and facilitating access to materials for crop improvement; it will also be a source of information to better inform decision-makers about conservation needs and strategies and potential material for crop improvement</td></tr>
<tr><td>Social</td><td>Enhanced knowledge about CWR, LR and traits of interest to improve crops in the face of climate change; the PGR Diversity Gateway can also serve as a platform to raise awareness about these crops and can contribute to better decision-making on policy for CWR and LR</td></tr>
<tr><td>Means of dissemination</td><td>Web, conferences, workshops, press, factsheets and papers</td></tr>
<tr><td>User community(ies)</td><td>• National PGR programmes
• Government agencies and NGOs involved in plant conservation
• Plant genebanks
• Protected area managers
• Plant breeding companies
• Scientists and policymakers in public and private research institutes
• The European Commission
• Farmers</td></tr>
</table>

4.1.5 Project website and contact details

The project website is available at www.pgrsecure.org and it is anticipated that the content will remain available until 2017.

Partner contact details

The main partner contacts and primary roles in the project are listed below. A full list of collaborators is available at: www.pgrsecure.bham.ac.uk/collaborators.

Partner 1, UOB

Project Coordinator, WP3 and WP7 leader

Dr Nigel Maxted, School of Biosciences, University of Birmingham, Edgbaston, Birmingham, B15 2TT, United Kingdom. Tel: +44 1214145571, Fax: +44 121 414 5925, Email: nigel.maxted@dial.pipex.com

Project Manager, WP3 collaborator

Ms Shelagh Kell, School of Biosciences, University of Birmingham, Edgbaston, Birmingham, B15 2TT, United Kingdom. Tel: +44 7801 369675, Email: s.kell@bham.ac.uk

Partner 2, DLO

WP1 leader

Dr Ben Vosman, Wageningen UR Plant Breeding, PO Box 16, 6700 AA, Wageningen, The Netherlands. Tel: +31 317480838, Fax: +31 317481094, Email: ben.vosman@wur.nl

WP5 leader

Dr Chris Kik, Centre for Genetic Resources, Droevendaalsesteeg 1, 6708 PB, Wageningen, The Netherlands. Tel: +31 317480861, Email: chris.kik@wur.nl

Partner 3, BIOVER

WP2 and WP6 leader

Dr Ehsan Dulloo, Bioversity International, Via dei Tre Denari 472/a, 00057 Maccarese, Rome, Italy. Tel: +39066118404, Fax: +390661979661, Email: e.dulloo@cgiar.org

Partner 4, UNIPG

WP4 leader

Prof Valeria Negri, Dipartimento di Scienze Agrarie, Alimentari e Ambientali, University of Perugia, Borgo XX Giugno 74, 06121 Perugia, Italy. Tel: +39 0755856218, Fax: +39 0755856224, Email: valeria.negri@unipg.it

Partner 5, JKI

WP5 collaborator

Dr Lothar Frese, Julius Kühn-Institut, Federal Research Centre for Cultivated Plants (JKI), Institute for Breeding Research on Agricultural Crops, Erwin-Baur-Str. 27, D-06484 Quedlinburg, Germany. Tel: +49 394647701, Fax: +49 394647255, Email: lothar.frese@jki.bund.de

Partner 6, NordGen

WP5 collaborator

Dr Anna Palmé, NordGen, Smedjevägen 3, SE23053 Alnarp, Sweden. Tel: +46 40536642, Fax: +46 40536650, Email: anna.palme@nordgen.org

Partner 7, MTT

WP3 and WP4 collaborator

Dr. Maarit Heinonen, MTT, ET-building, FI-31600 Jokioinen, Finland. Tel: +358 341883682, Fax: +358 341883244, Email: maarit.heinonen@mtt.fi

Partner 8, URJC

WP3 collaborator

Prof José Iriondo, Universidad Rey Juan Carlos, Dept. Biología y Geología, c/ Tulipán s/n, E28933 Móstoles, Madrid, Spain. Tel: +34 914888144, Fax: +34 916647490, Email: jose.iriondo@urjc.es

Partner 9, SXS

WP1 collaborators

Prof Bart Janssen, ServiceXS, Plesmanlaan 1d, The Netherlands. Tel: +31 715681050, Fax: +31 71 5681055, Email: b.janssen@servicexs.com

Dr Wilbert van Workum, ServiceXS, Plesmanlaan 1d, The Netherlands. Tel: +31 715681019, Email: wilbert.vanworkum@servicexs.com

Partner 10, UNOTT

WP1 collaborator

Prof Sean May, University of Nottingham, Sutton Bonington Campus, Loughborough, LE12 5RD, United Kingdom. Tel: + 44 7801568910, Fax: +44 1159513297, Email: sean@arabidopsis.org.uk

Associate Partner 11, EUCARPIA

WP5 collaborator

Dr Beat Boller, European Association for Research on Plant Breeding, Forschungsanstalt Agroscope Reckenholz-Tänikon ART, Reckenholzstrasse 191, CH-8046 Zürich, Switzerland. Tel: +41 443777363, Fax: +41 443777201, Email: beat.boller@art.admin.ch

www.pgrsecure.org

Project acronym: PGR Secure

Project Full Name: Novel characterization of crop wild relative and landrace resources as a basis for improved crop breeding

Final Report

Section 4.2: Use and dissemination of foreground

Contents

PGR Secure dissemination and exit strategies 3
Section A1: Scientific publications 3
Peer-reviewed journal papers 3
Peer-reviewed journal papers in preparation or submitted 3
Books 4
Book chapters 4
Papers in non-peer-reviewed journals and newsletters 5
Reports and databases 10
Newsletters 11
PhD theses 11
Section A2: Dissemination activities 12
Conferences and workshops 12
Oral communications 12
Poster presentations 15
Field exhibits 18
Videos 18

PGR Secure dissemination and exit strategies

An initial plan for use and dissemination of foreground was detailed in Annex I, Description of Work (www.pgrsecure.bham.ac.uk/sites/default/files/documents/contract_reporting/DOW_PGR_Secure_(266394)_2013-04-04.pdf). At the project's kick-off meeting in March 2011, dissemination and exit strategies per work package and per deliverable were drafted and these were updated during the project lifetime, as well as being reviewed and amended at each project consortium meeting. These documents are available in the partner intranet at: www.pgrsecure.bham.ac.uk/sites/default/files/documents/deliverables/Dissemination_strategy.pdf and www.pgrsecure.bham.ac.uk/sites/default/files/documents/deliverables/Exit_strategy.pdf.

Scientific publications and dissemination activities arising from the project are detailed in sections A1 and A2 below. A list of publications and presentations is also provided per work package in Appendix 1 of the third periodic report, as well as a list of publications and presentations per partner institute that are closely related to the project research.

Section A1: Scientific publications

Peer-reviewed journal papers

Garkava-Gustavssona, L., Mujajub, C., Sehic, J., Zborowska, A., Backes, G.M., Hietaranta, T. and Antonius, K. (2013) Genetic diversity in Swedish and Finnish heirloom apple cultivars revealed with SSR markers. *Scientia Horticulturae* 162, 43–48. DOI: 10.1016/j.scienta.2013.07.040

Landucci, F., Panella, L., Lucarini, D., Gigante, D., Donnini, D., Kell, S., Maxted, S., Venanzoni, R. and Negri, V. (2014) A prioritized inventory of crop wild relatives and wild harvested plants of Italy. *Crop Science* 54, 1628–1644. DOI: 10.2135/cropsci2013.05.0355.

Phillips, J., Kyratzis, A., Christoudoulou, C., Kell, S.P. and Maxted, N. (2014) Development of a national crop wild relative conservation strategy for Cyprus. *Genetic Resources and Crop Evolution* 61(4), 817–827. DOI: 10.1007/s10722-013-0076-z

Spataro, G. and Negri, V. (2013) The European seed legislation on conservation varieties: focus, implementation, present and future impact on landrace on farm conservation. *Genetic Resources and Crop Evolution* 60, 2421–2430. DOI: 10.1007/s10722-013-0009-x

Peer-reviewed journal papers in preparation or submitted

Kell, S., Maxted, N., Ford-Lloyd, B.V. *et al*. (in prep.). A methodological approach to complementary conservation of priority European CWR. *Journal to be decided.*

Landucci, F., Panella, L., Gigante, D., Donnini, D., Lucarini, D., Venanzoni, R. and Negri, V. Towards an *in situ* conservation strategy for wild plants of socio-economic interest: an example from Italy. *Genetic Resources and Crop Evolution*, submitted.

Rubio Teso, M.L., Parra-Quijano, M., Torres Lamas, E. and Iriondo, J.M. (in prep.) *In situ* and *ex situ* conservation status of CWR in Spain. Implications for conservation. *Genetic Resources and Crop Evolution*.

Rubio Teso, M.L., Thormann, I., Parra-Quijano, M., Dias, S., Van Etten, J. and Iriondo, J.M. (in prep.) An ecogeographical approach to optimizing focused identification germplasm strategy in crop wild relatives. *BMC Bioinformatics*.

Taylor, N.G., Kell, S., Holubec, V., Parra-Quijano, M., Chobot, K. and Maxted, N. (in prep.) A crop wild relative conservation strategy for the Czech Republic. *Journal to be decided.*

Books

Maxted, N., Ford-Lloyd, B. and Dulloo, M.E. (eds.) (2015) *Enhancing Crop Genepool Utilization: Capturing Wild Relative and Landrace Diversity for Crop Improvement*. CAB International, Wallingford, in prep.

Book chapters

Dias, S. et al. (2015) Plant Genetic Resources Diversity Gateway – a way forward. In: Maxted, N., Ford-Lloyd, B.V. and Dulloo, M.E. (eds.), *Enhancing Crop Genepool Utilization: Capturing Wild Relative and Landrace Diversity for Crop Improvement*. CAB International, Wallingford, in prep.

Dias, S. et al. (2015) Thoughts and experiences building an *in situ*/*ex situ* information system. In: Maxted, N., Ford-Lloyd, B.V. and Dulloo, M.E. (eds.), *Enhancing Crop Genepool Utilization: Capturing Wild Relative and Landrace Diversity for Crop Improvement*. CAB International, Wallingford, in prep.

Fielder, H. *et al*. (2015) Developing methodologies for the genetic conservation of UK crop wild relatives. In: Maxted, N., Ford-Lloyd, B.V. and Dulloo, M.E. (eds.), *Enhancing Crop Genepool Utilization: Capturing Wild Relative and Landrace Diversity for Crop Improvement*. CAB International, Wallingford, in prep.

Fitzgerald, H. *et al*. (2015) Developing a crop wild relative conservation strategy for Finland. In: Maxted, N., Ford-Lloyd, B.V. and Dulloo, M.E. (eds.), *Enhancing Crop Genepool Utilization: Capturing Wild Relative and Landrace Diversity for Crop Improvement*. CAB International, Wallingford, in prep.

Frese. L. *et al*. (2015) On the conservation and sustainable use of plant genetic resources in Europe: a stakeholder analysis. In: Maxted, N., Ford-Lloyd, B.V. and Dulloo, M.E. (eds.), *Enhancing Crop Genepool Utilization: Capturing Wild Relative and Landrace Diversity for Crop Improvement*. CAB International, Wallingford, in prep.

Frese. L. *et al*. (2015) Towards an improved European Plant Germplasm System. In: Maxted, N., Ford-Lloyd, B.V. and Dulloo, M.E. (eds.), *Enhancing Crop Genepool Utilization: Capturing Wild Relative and Landrace Diversity for Crop Improvement*. CAB International, Wallingford, in prep.

Heinonen, M. *et al*. (2015) Landrace inventories and conservation strategy making in Finland. In: Maxted, N., Ford-Lloyd, B.V. and Dulloo, M.E. (eds.), *Enhancing Crop Genepool Utilization: Capturing Wild Relative and Landrace Diversity for Crop Improvement*. CAB International, Wallingford, in prep.

Kell, S. *et al*. (2015) Europe's crop wild relative diversity: from conservation planning to conservation action. In: Maxted, N., Ford-Lloyd, B.V. and Dulloo, M.E. (eds.), *Enhancing Crop Genepool Utilization: Capturing Wild Relative and Landrace Diversity for Crop Improvement*. CAB International, Wallingford, in prep.

Iriondo, J.M. *et al.* (2015) National strategies for the conservation of CWR. In: Maxted, N., Ford-Lloyd, B.V. and Dulloo, M.E. (eds.), *Enhancing Crop Genepool Utilization: Capturing Wild Relative and Landrace Diversity for Crop Improvement*. CAB International, Wallingford, in prep.

Maxted, N. *et al*. (2015) Crop wild relative and landrace diversity characterization and conservation in Europe – recent advances and future needs. In: Maxted, N., Ford-Lloyd, B.V. and Dulloo, M.E. (eds.), *Enhancing Crop Genepool Utilization: Capturing Wild Relative and Landrace Diversity for Crop Improvement*. CAB International, Wallingford, in prep.

Maxted, N. *et al*. (2015) Joining up the dots: a systematic perspective on crop wild relative conservation and use. In: Maxted, N., Ford-Lloyd, B.V. and Dulloo, M.E. (eds.), *Enhancing Crop Genepool Utilization: Capturing Wild Relative and Landrace Diversity for Crop Improvement*. CAB International, Wallingford, in prep.

Negri, V. *et al.* (2015) Towards a European on-farm conservation strategy for landraces. In: Maxted, N., Ford-Lloyd, B.V. and Dulloo, M.E. (eds.), *Enhancing Crop Genepool Utilization: Capturing Wild Relative and Landrace Diversity for Crop Improvement*. CAB International, Wallingford, in prep.

Pelgrom, K. *et al*. (2015) Using Phenomics and Genomics to unlock landrace and wild relative diversity for crop improvement. In: Maxted, N., Ford-Lloyd, B.V. and Dulloo, M.E. (eds.), *Enhancing Crop Genepool Utilization: Capturing Wild Relative and Landrace Diversity for Crop Improvement*. CAB International, Wallingford, in prep.

Pritchard, J., Broekgaarden, C. and Vosman, B. (2013) Effects of climate change on plant–insect interactions and prospects for resistance breeding using genetic resources. In: Jackson, M, Ford-Lloyd, B. and Parry, M. (eds.), *Plant Genetic Resources and Climate Change*. CAB International, Wallingford. Pp. 270–284.

Rubio Teso, M.L. *et al*. (2015) Optimized site selection for the *in situ* conservation of forage and fodder CWR: a combination of community and genetic level perspectives. In: Maxted, N., Ford-Lloyd, B.V. and Dulloo, M.E. (eds.), *Enhancing Crop Genepool Utilization: Capturing Wild Relative and Landrace Diversity for Crop Improvement*. CAB International, Wallingford, in prep.

Thormann, I. *et al*. (2015) New predictive characterization methods for accessing and using CWR diversity. In: Maxted, N., Ford-Lloyd, B.V. and Dulloo, M.E. (eds.), *Enhancing Crop Genepool Utilization: Capturing Wild Relative and Landrace Diversity for Crop Improvement*. CAB International, Wallingford, in prep.

Torricelli, R. *et al*. (2015) Assessment of Italian LR density and species richness: useful criteria for developing *in situ* conservation strategies. In: Maxted, N., Ford-Lloyd, B.V. and Dulloo, M.E. (eds.), *Enhancing Crop Genepool Utilization: Capturing Wild Relative and Landrace Diversity for Crop Improvement*. CAB International, Wallingford, in prep.

Papers in non-peer-reviewed journals and newsletters

Asdal, Å., Phillips, J. and Maxted, N. (2013) Boost for crop wild relative conservation in Norway. *Crop Wild Relative* 9, 20–21. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_9.pdf

De la Rosa, L., Aguiriano, E., Mallor, C., Rubio-Teso, M.L., Parra-Quijano, M., Torres, E. and Iriondo, J.M. (2013) Prioritized CWR in Spain: status on the National Inventory of Plant Genetic Resources for Agriculture and Food. *Crop Wild Relative* 9, 23–26. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_9.pdf

Dias, S. (2012) Pieces of the puzzle—Trait Information Portal. *Crop Wild Relative* 8, 28–30. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_8.pdf

Dias, S. (2014) Plant Genetic Resources Diversity Gateway for the conservation and use of crop wild relative and landrace traits. *Crop Wild Relative* 10, in press.

Dias, S., Kell, S., Dulloo, E., Preston, J., Smith, L., Thörn, E. and Maxted, N. (2014) Enhanced genepool utilization – Capturing wild relative and landrace diversity for crop improvement. *Crop wild relative* 10, in press.

Fielder, H., Hopkins, J., Smith, C., Kell, S., Ford-Lloyd, B. and Maxted, N. (2012) UK wild species to underpin global food security: species selection, genetic reserves and targeted collection. *Crop Wild Relative* 8, 24–27. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_8.pdf

Fielder, H., Ford-Lloyd, B. and Maxted, N. (2014) Enhancing the conservation and use of *Medicago* genetic resources using Next-Generation Sequencing. *Crop Wild Relative* 10, in press.

Fitzgerald, H. and Korpelainen, H. (2014) Discovering Finnish crop wild relative diversity and gaps in their conservation. *Crop wild relative* 10, in press.

Fitzgerald, H., Korpelainen, H. and Veteläinen, M. (2013) Prioritization of crop wild relatives in Finland. *Crop Wild Relative* 9, 10–13. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_9.pdf

Frese, L., Palmé A., Bülow, L., Neuhaus, G. and Kik, C. (2014) On the conservation and sustainable use of plant genetic resources in Europe. *Crop wild relative* 10, in press.

Kell, S., Frese, L., Heinonen, M., Maxted, N., Negri, V., Palmé, A., Smith, L., Solberg, S. Ø. and Vosman, B. (2014) PGR Secure exhibits crop wild relatives and landraces at NIAB Innovation Farm. *Crop wild relative* 10, in press.

Heinonen, M. (2013) Ryvässipuli on vanha suomalainen sipuli. *Maatiainen* 3, 15–16.

Heinonen, M. and Antonius, K., (2012) Ongoing inventory on landrace potato onions in Finland. *Landraces* 1, 18.

Heinonen, M. and Kinnanen, H. (2012) MTT etsii pitkään viljeltyjen maatiaiskasvien tarinoita + faktaruutu: Huvitus löytyi muistitiedon avulla. *Maaseudun Tiede* 69(2), 5.

Heinonen, M. and Kinnanen, H. (2012) Etsitään tietoja omenan ja päärynän paikallislajikkeista. *Maatiainen* 3, 14–15.

Heinonen, M. and Kinnanen, H. (2013) Valtavan rakkaat vanhat omenapuut. *Geenivarat* (Newsletter for the Finnish National Genetic Resources Programmes) 2013, 21–22.

Heinonen, M. and Kinnanen, H. (2013) Kansallista hedelmäpuiden kokoelmaa täydennetään. *Geenivarat* (Newsletter for the Finnish National Genetic Resources Programmes) 2013, 23.

Heinonen, M. and Timonen, A. (2012) Maatiaisohran tie tuoteperheeksi vaati vuosien työn. *Maaseudun Tiede* 69(3), 2.

Heinonen, M. and Timonen, A. (2012) Maatiaisohran tie tuoteperheeksi vaati vuosien työn. *Maatiainen* /2012, 14–15.

Heinonen, M. and Veteläinen, M. (2014) Landrace conservation strategy for Finland. *Landraces* 3, in press.

Heinonen, M., Antonius, K., Ala-Kaarre, J. and Rihtilä, J. (2012) Suomessa 22 erilaista ryvässipulia. *Maaseudun Tiede* 69(4), 13.

Heinonen, M., Hartikainen, M. and Laamanen, J. (2012) Arvokkaat kasvit löytyvät tietokannoista. *Maaseudun Tiede* 69(2), 8.

Kell, S. and Maxted, N. (2012) The Palanga workshop: European PGRFA experts convene to develop national strategy protocols for CWR and landrace diversity conservation. *Crop Wild Relative* 8, 17–18. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_8.pdf

Kell, S., Ford-Lloyd, B. and Maxted, N. (2014) Europe's crop wild relative diversity: from conservation planning to conservation action. *Crop wild relative* 10, in prep.

Kik, C., Poulsen, G., Neuhaus, G. and Frese, L. (2012) PGR Secure: Engaging the user community. *Crop Wild Relative* 8, 10. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_8.pdf

Kinnanen, H. and Heinonen, M. (2012) Mistä on kestävät hedelmäpuut tehty? + faktaruutu: Etsintäkuulutus: omenat ja päärynät. *Puutarha&kauppa* 16(11), 12–13.

Landucci, F., Panella, L., Gigante, D., Donnini, D., Venanzoni, R., Torricelli, R. and Negri, V. (2012) Floristic and vegetation databases as tools for CWR surveys: a case study from Central Italy. *Crop Wild Relative* 8, 22–23. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_8.pdf

Maxted, N. and Kell, S. (2012) PGR Secure: enhanced use of traits from crop wild relatives and landraces to help adapt crops to climate change. *Crop Wild Relative* 8, 4–7. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_8.pdf

Maxted, N. and Kell, S. (2012) CWR horizon scanning: what are we doing and what should we be doing? *Crop Wild Relative* 8, 8–9. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_8.pdf

Maxted, N. and Kell, S. (2012) Towards a UK inventory of landrace diversity. *Landraces* 1, 16–17. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/Landraces_Issue_1.pdf

Maxted, N. and Kell, S.P. (2012) New EUCARPIA Partnership in EU FP7 Collaborative Project – Novel characterization of crop wild relative and landrace resources as the basis for improved plant breeding. *EUCARPIA Bulletin* 39, 27–31.

Maxted, N. and Kell, S.P. (2012) Joint PGR Secure/ECPGR Workshop: Conservation strategies for European crop wild relative and landrace diversity. *Bioversity Newsletter for Europe* 44, 3.

Maxted, N. and Kell, S. (eds.) (2013) *Crop wild relative Issue 9, October 2013.* 44 pp. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_9.pdf

Maxted, N. and Kell, S. (2014) Landrace conservation strategy for UK. *Landraces* 3, in press.

Maxted, N., Kell, S., Fielder, H. and Ford-Lloyd, B.V. (2011) *PGR Secure: project context, overview and links with the UK*. Oral communication, UK PGR Group meeting, 06 October 2011. http://ukpgrg.org/PGR_Secure_Kell_UKPGRG_Meeting_Oct_11.pdf

Maxted, N., Kell, S. and Fielder, H. (eds.) (2012) *Crop wild relative Issue 8, April 2012.* 44 pp. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_8.pdf

Negri, V. (2012) Towards an Italian inventory of landrace diversity. *Landraces* 1, 14–15. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/Landraces_Issue_1.pdf

Negri, V. and Maxted, N. (2012) PGR Secure Work package 4 'Landrace conservation': introduction and present achievements. *Landraces* 1, 8–9. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/Landraces_Issue_1.pdf

Negri, V. and Torricelli, R. (2012) Conservation strategies for European crop wild relative and landrace diversity: a joint PGR Secure/ECPGR workshop. *Landraces* 1, 10–13.

Negri, V. and Torricelli, R. (2013) Regional Laws Protect Genetic Resources in Italy. *Landraces* 2, 8–9. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/Landraces_Issue_2.pdf

Negri, V. and Torricelli, R. (2014) Landrace conservation strategy for Italy. *Landraces* 3, in press.

Pacicco, L., Bodesmo, M., Torricelli, R. and Negri, V. (2013) Progress towards an Italian conservation strategy for extant LR: the first Italian official inventory of LR. *Landraces* 2, 10. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/Landraces_Issue_2.pdf

Panella, L., Gigante, D., Donnini, D., Venanzoni, R. and Negri, V. (2012) Progenitori selvatici e forme coltivate di Apiaceae, Chenopodiaceae, Poaceae e Rosaceae: primi risultati per il territorio dell'Umbria (Italia Centrale). *Quaderni Botanica Ambientale ed Applicata* 23, 3–13.

Panella, L., Landucci, F., Donnini, D., Gigante, D., Venanzoni, R., Raggi, L., Torricelli, R. and Negri, V. (2014) Italian crop wild relatives and wild harvested plants conservation strategy. *Crop wild relative* 10, in press.

Pelgrom, K., Sharma, G., Broekgaarden, C., Voorrips, R., Bas, N., Pritchard, J., Ford-Lloyd, B. and Vosman, B. (2012) Looking for resistance to phloem feeders in *Brassica oleracea*. *Crop Wild Relative* 8, 12–14. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_8.pdf

Pelgrom, K., Broekgaarden, C., Voorrips, R. and Vosman, B. (2014) Successful use of crop wild relatives in breeding: easier said than done. *Crop wild relative* 10, in press.

Phillips, J., Kyratzis, A., Christodoulou, C., Kell, S. and Maxted, N. (2013) Development of a national crop wild relative conservation strategy for Cyprus. *Crop Wild Relative* 9, 16–19. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_9.pdf

Rubio Teso, M.L., Torres, M.E., Parra-Quijano, M. and Iriondo, J.M. (2012) Prioritization of crop wild relatives in Spain. *Crop Wild Relative* 8, 18–21. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_8.pdf

Rubio Teso, M.L., Torres, M.E., Parra-Quijano, M. and Iriondo, J.M. (2012) Parientes silvestres de cultivos (PSC) en España: priorización y necesidades. *Conservación Vegetal* 16, 6–8. www.uam.es/otros/consveg/documentos/numero16.pdf

Rubio Teso, M.L., Ronquillo Ferrero, C., Nebreda Trejo, A., Parra Quijano, M., Torres Lamas, E. and Iriondo Alegría J.M. (2014) *In situ* conservation of CWR in Spain. Present and future. *Crop wild relative* 10, in press.

Rubio Teso, M.L., Parra-Quijano, M., Torres Lamas, E. and Iriondo, J.M. (in prep.) National Inventory of CWR in Spain. *Spanish Journal of Agricultural Research.*

Suojala-Ahlfors, T., Heinonen, M., Antonius, K., Heinonen, A., Laamanen, J., Pihlava, J-M. and Mattila, P. (2014) Ryvässipuli takaisin viljelyyn ja käyttöön [Potato onion back to cultivation and use in Finland]. In: Kiviharju, Elina (ed.). *Viljelykasvien Geenivarat Talteen ja Käyttöön – Suomen Kansallisen Asvigeenivaraohjelman 10-Vuotisseminaarin* (29.8.2014) satoa. MTT Raportti 139. Pp. 81–82. https://portal.mtt.fi/portal/page/portal/www/Tietopaketit/Kasvigeenivarat/mttraportti139.pdf

Taylor, N.G., Kell, S., Holubec, V., Parra-Quijano, M., Chobot, K. and Maxted, N. (2013) Systematic conservation planning for the Czech Republic. *Crop Wild Relative* 9, 5–9. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_9.pdf

Thormann, I. (2012) Applying FIGS to crop wild relatives and landraces in Europe. *Crop Wild Relative* 8, 14–16. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_8.pdf

Thormann, I., Parra-Quijano, M., Iriondo, J.M., Rubio-Teso, M.L., Endresen, D.T., Maxted, N., Dias, S. and Dulloo. M.E. (2014) Two predictive characterization approaches to search for target traits in crop wild relatives and landraces. *Crop Wild Relative* 10, in press.

Torricelli, R. and Negri, V. (2014) Examples of landraces grown in Italy. *Landraces* 3, in press.

Veloso, M.M., Reis, P. and Machado, D. (2014) On farm conservation of olive tree (*Olea europaea*) landraces at Vila Verde de Ficalho (Portugal). *Landraces* 3, in press.

Vosman, B. (2012) A phenomics and genomics approach to the use of landraces and crop wild relatives for crop improvement. *Crop Wild Relative* 8, 11–12. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_8.pdf

Vosman, B., Pelgrom, K., Sharma, G., Vooripps, R., Broekgaarden, C., Pritchard, J., May, S., Adobor, S., Castellanos-Uribe, M., van Kaauwen, M., Janssen, B., van Workum, W. and Ford-Lloyd, B. (2014) Phenomics and genomics tools for facilitating brassica improvement. *Crop wild relative* 10, in press.

Reports and databases

Heinonen, M. and Veteläinen, M. (2011) *Cereal landrace farmers in Finland and their motivation to on-farm conservation*. NJF Report vol. 7 no. 1. Pp. 51–55.

Heinonen, M. and contributors (2014) *Landrace* In Situ *Conservation Strategy for Finland*. MTT Report 163. 44 pp. ISBN 978-952-487-570-7. http://urn.fi/URN:ISBN:978-952-487-570-7

Heinonen, M., Fitzgerald, H., Veteläinen, M. and Korpelainen, H. (2014) Suomalaisten maatiaiskasvien ja viljelykasvien luonnonvaraisten sukulaisten *in situ* -suojelustrategioiden valmisteleminen [Towards *in situ* conservation strategies of landraces and crop wild relatives in Finland] In: Kiviharju, E. (ed.), *Viljelykasvien Geenivarat Talteen ja Käyttöön – Suomen Kansallisen Asvigeenivaraohjelman 10-Vuotisseminaarin* (29.8.2014) satoa. MTT Raportti 139. Pp. 68–69. https://portal.mtt.fi/portal/page/portal/www/Tietopaketit/Kasvigeenivarat/mttraportti139.pdf

Heinonen, M., Kinnanen, H., Valo, R., Antonius, K. and Ala-Kaarre, J. (2014) Nurkkapuut kansan sydämessä [Seed born apple trees in Finland]. In: Kiviharju, E. (ed.), *Viljelykasvien Geenivarat Talteen ja Käyttöön – Suomen Kansallisen Asvigeenivaraohjelman 10-Vuotisseminaarin* (29.8.2014) satoa. MTT Raportti 139. Pp. 40–43. https://portal.mtt.fi/portal/page/portal/www/Tietopaketit/Kasvigeenivarat/mttraportti139.pdf

Kell, S., Negri, V., Torricelli, R., Maxted, N., Maggioni, L. and Fielder, H. (compilers) (2012) *Conservation Strategies for European Crop Wild Relative and Landrace Diversity. Report of the Joint PGR Secure/ECPGR Workshop, 7–9 September 2011, Palanga, Lithuania*. www.pgrsecure.bham.ac.uk/sites/default/files/meetings/palanga/CWR_and_LR_Workshop_Report_FINAL.pdf

Maxted, N., Avagyan, A. Frese, L., Iriondo, J.M., Magos Brehm, J., Singer, A. and Kell, S.P. (2013) *Preserving Diversity: A Concept for In Situ Conservation of Crop Wild Relatives in Europe.* Rome, Italy: *In Situ* and On-farm Conservation Network, European Cooperative Programme for Plant Genetic Resources, Rome, Italy. www.pgrsecure.org/documents/Concept.pdf

Maxted, N., Magos Brehm, J. and Kell, S.P. (2013) *Resource Book for Preparation of National Conservation Plans for Crop Wild Relatives and Landraces*. Commission on Genetic Resources for Food and Agriculture. Food and Agriculture Organization of the United Nations, Rome, Italy. 457 pp. www.fao.org/agriculture/crops/thematic-sitemap/theme/seeds-pgr/resource-book/en/

Negri, V., Maxted, N., Torricelli, R., Heinonen, M., Vetelainen, M. and Dias, S. (2012) *Descriptors For Web-Enabled National* In Situ *Landrace Inventories*. 18 pp. www.pgrsecure.bham.ac.uk/sites/default/files/documents/helpdesk/LRDESCRIPTORS_PGRSECURE.pdf

Negri, V., Pacicco, L., Bodesmo, M. and Torricelli, R. (2013) *The First Italian Inventory of In Situ Maintained Landraces*. On CD ROM. ISBN 978-88-6074-279-7. Morlacchi Editrice, Perugia. Also available from http://vnr.unipg.it/PGRSecure. ISBN 978-88-6074-279-7.

Negri, V., Freudenthaler, P., Gasi, F., Goldringer, I., Mendes Moreira, P., Strãjeru, S., Tan, A., Veteläinen, M., Voegel, R., Weibull, J. and Maxted, N. (2014) *The ECPGR Concept for* In Situ *(On-Farm) Conservation in Europe*. Rome, Italy: *In Situ* and On-farm Conservation Network, European Cooperative Programme for Plant Genetic Resources, Rome, Italy. Available at: www.pgrsecure.org/documents/OnFarm_Conservation_Concept.pdf

Pepe, A., Pacicco, L, Torricelli, R. and Negri, V. (2012) *Tool for recording national in situ landrace inventory data*. www.pgrsecure.bham.ac.uk/sites/default/files/documents/helpdesk/PGR_Secure_LR_data_recording_tool.zip

Thormann, I., Parra-Quijano, M., Iriondo, J.M., Rubio-Teso, M.L., Endresen, D.T., Dias, S., van Etten, J. and Maxted, N. (2014) *Predictive Characterization of Crop Wild Relatives and Landraces. Technical Guidelines Version 1.* Bioversity International, Rome, Italy, in press.

Newsletters

Kell, S., Maxted, N. and Fielder, H. (eds.) (2012) *Crop wild relative Issue 8, April 2012.* 44 pp. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_8.pdf

Kell, S. and Maxted, N. (eds.) (2013) *Crop wild relative Issue 9, October 2013.* 44 pp. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_9.pdf

Kell, S. and Maxted, N. (eds.) (2014, in press) *Crop wild relative Issue 10, November 2014.* www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/CWR_Issue_10.pdf

Negri, V., Torricelli, R. and Maxted, N. (eds.) (2012) *Landraces Issue 1, October 2012.* 31 pp. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/Landraces_Issue_1.pdf

Negri, V., Torricelli, R. and Maxted, N. (eds.) (2013) *Landraces Issue 2, October 2013.* 24 pp. www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/Landraces_Issue_2.pdf

Negri, V., Torricelli, R. and Maxted, N. (eds.) (2014 in press) *Landraces Issue 3, December 2014.* www.pgrsecure.bham.ac.uk/sites/default/files/documents/newsletters/Landraces_Issue_3.pdf

PhD theses

Fielder, H. (2015) *Developing methodologies for the genetic conservation of UK crop wild relatives*. PhD Thesis. University of Birmingham, UK, in prep.

Sharma, G. (2015) *Novel approaches for evaluating* Brassica *germplasm for insect resistance*. PhD Thesis. University of Birmingham, UK, in prep.

Section A2: Dissemination activities

Conferences and workshops

Joint PGR Secure/ECPGR workshop, 'Conservation strategies for European crop wild relative and landrace diversity', 7–9 September 2011, Hotel Palangos vėtra, Palanga, Lithuania. www.pgrsecure.bham.ac.uk/palanga_workshop

PGR Secure stakeholder workshop: 'On the conservation and sustainable use of plant genetic resources in Europe: a stakeholder analysis', 26–28 November 2013, Wageningen, the Netherlands. www.nordgen.org/index.php/en/content/view/full/2481/

Joint PGR Secure/EUCARPIA conference, 'Enhanced Genepool Utilization – Capturing wild relative and landrace diversity for crop improvement', incorporating the PGR Secure final dissemination conference, 16–20 June 2014, NIAB Innovation Farm and Churchill College, Cambridge, UK. www.pgrsecure.org/conference

Dias, S., Dulloo, E., Maxted, N., Kell, S., Thörn, E., Smith, L., Preston, J. and Hutchinson, S. (eds.) (2014) *International Conference on Enhanced Genepool Utilization – Capturing wild relative and landrace diversity for crop improvement, Cambridge, United Kingdom, 16–20 June 2014. Book of Abstracts.* Bioversity International, Rome, Italy. www.pgrsecure.bham.ac.uk/sites/default/files/documents/public/PGR_Secure_conference_abstracts.pdf

Oral communications

Broekgaarden, C., Riviere, P., Steenhuis, G., Del sol Cuenca, M., Kos, M., Pelgrom, K., Voorrips, R. and Vosman, B. (2013) *Phloem-specific resistance in* Brassica oleracea *against the whitefly* Aleyrodes proletella*.* Oral communication, 6th meeting of the IOBC-WPRS Working Group 'Induced resistance in plants against insects and diseases', June 10–13 2013, Avignon, France.

Dias, S. (2013) *EURISCO, GENESYS and the TIP: an update*. Oral communication, UK PGR Group meeting, London, UK, 13 March 2013. Available at: http://ukpgrg.org/01-SDias_UKPGR_13March2013.pdf

Dias, S. and Skofic, M. (2014) *Thoughts and experiences building an* in situ/ex situ *information system*. Oral communication, 'Enhanced genepool utilization – Capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Dias, S., Skofic, M., Dulloo, E. and Maxted, N. (2014) *Plant Genetic resources Diversity gateway – a way forward*. Oral communication, 'Enhanced genepool utilization – Capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Fielder, H., Hosking, J., Brotherton, P., Woodman, J., Smith, S., Hopkins, J., Ford-Lloyd, B. and Maxted N. (2014) *Developing methodologies for the genetic conservation of UK crop wild relatives*. Oral communication, 'Enhanced genepool utilization – Capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Frese, L. (2011) *Conservation and use of crop wild relatives*. Oral communication, IIRB Study Group meeting 'Genetics and Breeding', AIMCRA, Valladolid, Spain, 22–23 September 2011.

Frese, L., Kik, C. and Palmé, A. (2013) *On the conservation and sustainable use of plant genetic resources in Europe: a stakeholder analysis*. Oral communication, IV Symposium International: Gestion des Ressources et Applications Biotechnologiques en Aridoculture et Cultures Oasiennes, Djerba, Tunisia, 17–19 December 2013.

Frese L., Palmé A., and Kik C. (2014) *On the conservation and sustainable use of plant genetic resources in Europe: a stakeholder analysis*. Oral communication, 'Enhanced genepool utilization – capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Frese L., Palmé A., Bülow, L. and Kik, C. (2014) *Towards an improved European plant germplasm system*. Oral communication, 'Enhanced genepool utilization – capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Heinonen, M., Kinnanen, H., Valo, R., Antonius, K. and Ala-Kaarre, J. (2013) *Nurkkapuut Kansan Sydämessä*. Keynote oral communication at Finnish national plant genetic programme's 10th anniversary seminar, 29 August 2013, Jokioinen, Finland. www.mtt.fi/kasvigeenivarat

Heinonen, M. (2014) *Heritage varieties* ex situ *and* in situ *in Finland*. Keynote oral presentation at NJF seminar 474 'Nordic heritage varieties of cereals', Mariehamn, Finland, 15-17 July 2014.

Heinonen, M., Antonius, K., Kinnanen, H. and Valo, R. (2014) *Landrace inventories and conservation strategy making in Finland*. Oral communication, 'Enhanced genepool utilization – Capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Iriondo, J.M. (2014) *Origen silvestre de las plantas cultivadas: ¿por qué resulta tan importante ahora?* Oral communication (invited speaker), Conferences of the Jardin Atlántico Botanical Garden, Gijón, Spain, 26 June 2014.

Iriondo, J.M., Parra-Quijano, M., Rubio-Teso, M.L., Torres, E. and García, R. (2013) *Ecogeographical approaches to characterize CWR adaptive traits useful for crop adaptation*. Oral communication, EUCARPIA Genetic Resources section meeting, 'Pre-breeding – fishing in the gene pool', June 10–13 2013, Alnarp, Sweden.

Iriondo, J.M., Kell, S.P., Fitzgerald, H., Negri, V., Magos Brehm, J. and Maxted, N. (2014) *National strategies for the conservation of CWR*. Keynote oral communication, 'Enhanced genepool utilization – Capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Kell, S., Iriondo, J., Magos Brehm, J., Ford-Lloyd, B., Harris, C. and Maxted, N. (2014) *Europe's crop wild relative diversity: from conservation planning to conservation action*. Oral communication. 'Enhanced genepool utilization – Capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Maxted, N., Dias, S., Fielder, H., Fitzgerald, H., Iriondo, J.M., Landucci, F., Negri, V.,Rubio, L., Taylor, N. and Kell, S. (2013) *Nurturing the gene pool: National strategies for crop wild relative conservation and use.* Oral communication, EUCARPIA Genetic Resources section meeting, 'Pre-breeding–fishing in the gene pool', 12 June 2013, Alnarp, Sweden.

Maxted, N., Amri, A., Castañeda Álvarez, N., Dias, S., Dulloo, M.E., Fielder, H., Ford-Lloyd, B.V., Iriondo, J.M., Magos Brehm, J., Nilsen, L-B., Thormann, I., Vinvent, H. and Kell, S. (2014) *Joining up the dots: a systematic perspective on crop wild relative conservation and use*. Keynote oral communication, 'Enhanced genepool utilization – Capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Negri, V., Gigante, D., Donnini, D., Torricelli, R., Landucci, F., Panella, L. and Venanzoni, R. (2013) *Attività del DBA_UNIPG per la salvaguardia dei progenitori selvatici delle piante coltivate nell'ambito del progetto EC FPVII PGR Secure*. Oral communication, Banche di germoplasma e conservazione *in situ* scientific meeting, Orto Botanico, Rome, 23 April 2013.

Negri, V., Heinonen, M., Mendes Moreira, P., Torricelli, R. and Maxted, N. (2013) *Developing a European on farm conservation strategy for landraces.* Oral communication, EUCARPIA Genetic Resources section meeting, 'Pre-breeding – fishing in the gene pool', 10–13 June 2013, Alnarp, Sweden. www.nordgen.org/ngdoc/nordgen/Eucarpia/oral_presentations/Valeria_Negri.pdf

Negri, V., Heinonen, M., Moreira Mendes, P., Torricelli, R. and Maxted N. (2013) *Developing a European in situ (on farm) conservation strategy for landraces (LR).* Oral communication, EUCARPIA Genetic Resources section meeting, 'Pre-breeding – fishing in the gene pool', 10–13 June 2013, Alnarp, Sweden.

Negri, V., Maxted, N., Torriceli, R. and Heinonen, M. (2014) *Towards a European on-farm conservation strategy for landraces.* Oral communication, 'Enhanced genepool utilization – Capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Negri, V., Torricelli, R., Maxted, N. and Heinonen, M. (2014) European landrace conservation. *Landraces* 3, in press.

Palmé, A. (2012) *Utilizing crop wild relatives in the Baltic sea region: some initial findings in the EU project PGR Secure*. Oral communication, 'Diversity in plant breeding and agriculture: strategies for healthy lifestyle', State Stende Cereals Breeding Institute, Latvia, May 30–June 01 2012.

Parra-Quijano, M., López, F., Torres, E. and Iriondo, J.M. (2014) *CAPFITOGEN tools. Facilitated spatial and ecogeographical germplasm analysis for efficient PGR conservation and utilization*. Oral communication, 'Enhanced genepool utilization – Capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Pelgrom, K. (2012) *Host plant resistance to cabbage whitefly in Brassica oleracea and wild relatives*. Oral communication, NWO-ALW meeting 'Experimental Plant Sciences', Lunteren, The Netherlands, 03 April 2012.

Pelgrom, K., Sharma, G., Voorrips, R., Broekgaarden, C., Pritchard, J., May, S., Adobor, S., Janssen, B., van Workum, W., Ford-Lloyd, B. and Vosman, B. (2014) *Using phenomics and genomics to unlock landrace and wild relative diversity for crop improvement*. Oral communication, 'Enhanced genepool utilization – Capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Rubio-Teso, M.L., Parra-Quijano, M. and Iriondo, J.M. (2013) *Finding the most drought-resistant plant populations. Evaluation of the FIGS methodology.* Oral communication, XI National Congress of the Spanish Association of Terrestrial Ecology. Pamplona/Iruña 6–10 May 2013.

Rubio Teso, M.L., Parra-Quijano, M., Ronquillo-Ferrero, C., Nebreda, A., Torres, E. and Iriondo, J.M. (2013) *Hacia la estrategia de conservación de parientes silvestres de cultivos. Diversidad genética de valor adaptativo en espacios naturales protegidos.* Oral communication, XI Congress of Plant Conservation Biology, Murcia, Spain, 15–18 October 2013.

Rubio Teso, M.L., Ronquillo Ferrero, C., Torres Lamas, E., Parra Quijano, M. and Iriondo Alegría, J.M. (2013) *Evaluación del estado de conservación* in situ *y diversidad de parientes silvestres de cultivos para la alimentación y forraje*. Oral communication, IV Congress of Biodiversity, Bilbao, Spain, 6–8 February 2013. http://congresobiodiversidad.com/comunicaciones-orales/

Rubio Teso, M.L., Kinoshita-Kinoshita, K. and Iriondo, J.M. (2014) *Optimized site selection for the* in situ *conservation of forage and fodder CWRs: a combination of community and genetic level perspectives*. Oral communication, 'Enhanced genepool utilization – Capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Thormann, I., Parra-Quijano, M., Iriondo, J.M., Rubio-Teso, M.L., Endresen, D.T., Dias, S., van Etten, J. and Maxted, N. (2014) *New predictive characterization methods for accessing and using CWR diversity*. Oral communication, 'Enhanced genepool utilization – Capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Torricelli, R., Pacicco, L., Bodesmo, M., Raggi, L. and Negri, V. (2014) *Assessment of Italian LR density and species richness: useful criteria for developing in situ conservation strategies*. Oral communication, 'Enhanced genepool utilization – Capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Vosman, B. (2013) *High throughput screening of plant collections for increased resistance towards phloem feeding insects*. Oral communication, annual meeting of the Entomological Society of America. 10–13 November 2013, Austin, USA.

Vosman, B. (2013) *Breeding for insect resistant crops*. Oral communication, mini-symposium on novel technologies to study plant/herbivore interactions. Arkansas State University, 8 November 2013, Jonesburo, USA.

Vosman, B. (2013) *Novel characterization techniques: the phenomics and genomics approach*. Oral communication, PGR Secure workshop, 'On the conservation and sustainable use of plant genetic resources in Europe: a stakeholder analysis', Wageningen, The Netherlands, 25–29 November 2013.

Vosman, B. (2014) *Insect resistance in vegetable crops*. Oral communication, Applied Vegetables Genomics Conference, Vienna, 19–20 February 2014.

Poster presentations

Fitzgerald, H., Heinonen, M., Korpelainen, H. and Veteläinen, M. (2013) *Towards the Finnish LR and CWR conservation strategies.* Poster presented at the EUCARPIA Genetic Resources section meeting, 'Pre-breeding – fishing in the gene pool', 10–13 June 2013, Alnarp, Sweden.

Fitzgerald, H., Korpelainen, H. and Veteläinen, M. (2014) *Developing a crop wild relative conservation strategy for Finland*. Poster presentation, 'Enhanced genepool utilization – Capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Frese L., Palmé A. and Kik C. (2014) *Towards an improved European plant germplasm system*. Poster presented at the Third Nordic International Conference on Climate Change Adaptation: Adapting to Change: From Research to Decision-making, Copenhagen, Denmark, 25–27 August 2014.

Heinonen, M., Fitzgerald, H., Veteläinen, M. and Korpelainen, H. (2013) *Suomalaisten Maatiaiskasvien ja Viljelykasvien Luonnonvaraisten Sukulaisten in situ Suojelustrategioiden Valmisteleminen*. Poster and abstract at Finnish national plant genetic programme's 10th anniversary seminar, 29 August 2013, Jokioinen, Finland. www.mtt.fi/kasvigeenivarat

Pacicco, L., Bodesmo, M., Torricelli, R. and Negri, V. (2013) *The First Italian Inventory of In Situ Maintained Landraces.* Poster presented at the 57th Annual Congress of Societa' Italiana di Genetica Agraria, Foggia, 16–19 September 2013.

Palmé, A., Solberg, S.Ø., Ottosson, F., Poulsen, G., Frese, L. and Kik, C. (2013) *Constraints in the Utilization of Plant Genetic Resources in the Nordic Countries*. Poster presented at the EUCARPIA Genetic Resources section meeting: 'Pre-breeding – fishing in the gene pool', 10–13 June 2013, Alnarp, Sweden.

Panella, L., Donnini, D., Gigante, D., Negri, V. and Venanzoni, R. (2011) Crop Wild Relatives of *Apium*, *Avena*, *Beta*, *Brassica* and *Prunus* genera in Umbria. Poster presented at the 106° Società Botanica Italiana Congress, Genova (I) 21–24 September 2011.

Panella, L., Landucci, F., Gigante, D., Donnini, D., Lucarini, D., Venanzoni, R., Torricelli, R. and Negri, V. (2013) *Crop wild relatives and wild harvested plants of Italy*. Poster presented at the 57th Annual Congress of Societa' Italiana di Genetica Agraria, Foggia, Italy, 16–19 September 2013.

Pelgrom, K., Broekgaarden, C., Voorrips, R. and Vosman, B. (2014) *Mapping and validation of QTLs for resistance to whitefly in cabbage.* Poster presentation, 'Enhanced genepool utilization – Capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Phillips, J., Asdal, Å. and Maxted, N. (2014) *National implementation of the conservation of plant genetic resources within Norway.* Poster presentation, 'Enhanced genepool utilization – Capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Raggi, R., Panella, L., Landucci, F., Gigante, D., Venanzoni, R. and Negri, V. (2013) *Brassica crop wild relatives in central Italy*. Poster presented at the VI International Symposium on Brassicas and XVIII Crucifer Genetics Workshop, Catania, Italy, 12–16 November 2013.

Raggi, R., Panella, L., Landucci, F., Torricelli, R., Venanzoni, R. and Negri, V. (2014) *A gap analysis for* Brassica incana *Ten. and* B. montana *Pourr. Present in Italy.* Poster presentation, 'Enhanced genepool utilization – Capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Sharma, G., Pritchard, J. and Ford-Lloyd, B. (2014) *Looking for insect resistance in brassicas: combining physiology with plant transcriptomics to identify new sources of resistance and candidate genes*. Poster presentation, 'Enhanced genepool utilization – Capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Suojala-Ahlfors, T., Heinonen, M., Antonius, A., Heinonen, A., Mattila P. and Pihlava, J-M. (2013) *Ryvässipuli – Perinnekasvi Takaisin Viljelyyn ja Käyttöön*. Poster at Finnish national plant genetic programme's 10th anniversary seminar, 29 August 2013, Jokioinen, Finland. www.mtt.fi/kasvigeenivarat

Thormann, I., Rubio Teso, M.L., Parra Quijano, M. and Iriondo, J.M. (2014) *Predictive characterization of* Beta *CWR using the ecogeographical filtering method*. Poster presentation, 'Enhanced genepool utilization – Capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Torricelli, R., Landucci, F., Panella, L. Donnini, D., Gigante, D., Venanzoni, R., Raggi, L. and Negri, V. (2014) *First steps towards and Italian conservation strategy for crop wild relatives and wild harvested plants.* Poster presentation, 'Enhanced genepool utilization – Capturing wild relative and landrace diversity for crop improvement', Cambridge, UK, 16–20 June 2014.

Vosman, B., Pelgrom, K., Voorrips, R. and Broekgaarden, C. (2013) *Breeding for cabbage whitefly resistance in* Brassica oleracea*.* Poster presented at the conference 'Future IPM in Europe', 19–21 March 2013, Riva del Garda, Italy.

Calls for landraces (related to WP4, Landrace conservation): Posters and other material (in Finnish and Swedish)

Heinonen, M. (2012) Valtavan rakas / Hugely loved / Högt älskade fruktträd. MTT elo-blog 14 January 2012, mttelo.mtt.fi

Heinonen, M. and Kinnanen, H. (2012) Paikalliset hedelmälajikkeet. [Call for LR apples and pears in Finland]

Heinonen, M. and Kinnanen, H. (2012) Missä kasvaa hämäläisiä vanhoja omenalajikkeita? [Call for LR apples in southern Finland]

Heinonen, M. and Kinnanen, H. (2012) Missä kasvaa savolaisia vanhoja omenalajikkeita? [Call for LR apples in central Finland]

Heinonen, M. and Kinnanen, H. (2012) Missä kasvaa lounaissuomalaisia vanhoja omenalajikkeita? [Call for LR apples in southwest Finland]

Heinonen, M. and Kinnanen, H. (2012) Missä kasvaa lounaissuomalaisia vanhoja päärynälajikkeita? [Call for LR pears in southwest Finland]

Heinonen, M. and Kinnanen, H. (2012) Inhemska äpplen och päron vid Finska viken [Call for LR apples and pears in coastal Finland]

Heinonen, M. and Kinnanen, H. (2013) Missä kasvaa uusmaalaisia vanhoja omenalajikkeita? [Call for LR apples in south Finland]

Kinnanen H. and Mäkinen K. (2013) Omenakalenteri 2013. Suomalaisia maatiaislajikkeita [Native Apple Annual Calendar 2013]

Field exhibits

NIAB Innovation Farm was host institute and sponsor of the joint PGR Secure/EUCARPIA conference, 'ENHANCED GENEPOOL UTILIZATION – capturing wild relative and landrace diversity for crop improvement' convened in Cambridge, UK, 16–20 June 2014. NIAB has a particular strength in practical translation of research to products and Innovation Farm forms the user interface between growers, industry and the research community by working to improve knowledge exchange and to facilitate practical and profitable relationships in order to harness the full potential of plant genetic innovations. One of NIAB Innovation Farm's main facilities is 2 ha of land devoted to exhibiting plant genetic resources in field plots and in glasshouses adjacent to a visitor centre containing seminar and networking facilities. The PGR Secure consortium took advantage of this opportunity to display crop wild relative (CWR) and landrace material to raise awareness of the value of these plant genetic resources for food and agriculture (PGRFA) and to provide a means of attracting users of the material. A series of information sheets were prepared and provided to visitors to the NIAB Innovation Farm.

Information sheets

Frese, L. (2014) *The sugar beet crop gene pool*. PGR Secure information sheet to accompany field exhibit, NIAB Innovation Farm, Cambridge, UK. www.pgrsecure.org/sites/default/files/documents/public/Exhibits/sugarbeet.pdf

Heinonen, M. (2014) *Landrace potato onions in Finland*. PGR Secure information sheet to accompany field exhibit, NIAB Innovation Farm, Cambridge, UK. www.pgrsecure.org/sites/default/files/documents/public/Exhibits/potato_onion.pdf

Heinonen, M., Timonen, A. and Kell, S. (2014) *Landrace hulless barley 'Jorma'*. PGR Secure information sheet to accompany field exhibit, NIAB Innovation Farm, Cambridge, UK. www.pgrsecure.org/sites/default/files/documents/public/Exhibits/hulless_barley.pdf

Solberg, S. Ø. and Palmé, A. (2014) *Forages from the Nordic countries*. PGR Secure information sheet to accompany field exhibit, NIAB Innovation Farm, Cambridge, UK. www.pgrsecure.org/sites/default/files/documents/public/Exhibits/Nordic_forages.pdf

Solberg, S. Ø. and Palmé, A. (2014) *Vegetables and herbs from the Nordic region*. PGR Secure information sheet to accompany field exhibit, NIAB Innovation Farm, Cambridge, UK. www.pgrsecure.org/sites/default/files/documents/public/Exhibits/Nordic_vegetables.pdf

Vosman, B. (2014) *Breeding insect-resistant brassica crops*. PGR Secure information sheet to accompany field and glasshouse exhibits, NIAB Innovation Farm, Cambridge, UK. www.pgrsecure.org/sites/default/files/documents/public/Exhibits/brassicas.pdf

Videos

Crop wild relatives – a key asset for sustainable agriculture. Bioversity International, Rome, Italy. www.bioversityinternational.org/news/detail/new-video-on-crop-wild-relatives/; www.youtube.com/watch?feature=player_embedded&v=Ah7RruMZ9CU