Networking, partnerships and tools to enhance *in situ* conservation of European plant genetic resources

ISSN 1742-3694 (Online)

www.farmerspride.eu

Crop wild relative

Issue 11 June 2019

Conserving plant genetic resources for use now and in the future

Farmer's Pride - EU Horizon 2020 Framework Programme - Project 774271

Farmer's Pride

Crop wild relative

Issue 11 June 2019

Contents

Editor:
Nigel Maxted

Design by:
Shelagh Kell

Layout by:
rjpdesign.co.uk

Front cover:
Malus sieversii (Wild apple) in Kazakstan

Photo:
Nigel Maxted

Correspondence address:
Nigel Maxted, School of Biosciences, University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK
Email: n.maxted@bham.ac.uk

Editorial

We are pleased to welcome you to Issue 11 of *Crop wild relative*—the first issue to be published in the context of the *Farmer's Pride*, a Collaborative Project funded under the EU Horizon 2020 Programme. The *Farmer's Pride* project (full title: *Networking, Partnerships and Tools to Enhance in situ Conservation of European Plant Genetic Resources*) focuses on building a collaborative network for on-site conservation and sustainable use of Europe's plant diversity for food, nutrition and economic security throughout the region.

In times of global transformation – including the rapidly increasing human population and climate change – greater diversity is needed to sustain food supplies than ever before as the environmental conditions in which crops are cultivated become more extreme, changeable and uncertain. Our plant genetic resources, our crop plants, their related wild species and the breadth of genetic diversity within them contain enough diversity to sustain our food, nutrition and economic security. Yet a range of factors driven by anthropogenic pressures and economic interests are threatening the breadth of genetic diversity that are essential to sustain crop improvement.

Although around the world, many organizations and individuals are working hard to conserve plant genetic resources, a step change in required to move from the current *ad hoc ex situ* conservation to a more systematic, complementary conservation basis for CWR conservation that involves both evidence-based *ex situ* and *in situ* interventions. Given that historically European CWR conservation has focused on population samples held *ex situ* as seed in gene banks and that although CWR diversity is found in numerous protected areas, here it is not actively conserved (= the populations are not actively managed to maximise genetic diversity maintenance) or available to users, then in time **the impact of a more systematic, complementary approach to CWR conservation is likely to more than double the genetic diversity available to breeders and farmers for crop improvement**.

In Europe to achieve this objective Farmer's Pride is bringing together key actors to create a self-sustaining network for *in situ* CWR and LR conservation throughout the region. The project is building on existing mechanisms, such as Europe's existing Natura 2000 network of protected area system, agricultural gene banks and numerous stakeholder organizations, to collectively identify and establish a novel network of sites and custodians of crop wild relative and landrace diversity, as well as the governance structures needed to ensure effective functioning and longevity.

This issue of *Crop wild relative (*issue 11) is focused on showcasing various of the products that Farmer's Pride will achieve. The review will commence with a review of the Farmer's Pride Project (pages 4–10), followed by articles discussing why we need to supply conservation incentives for agrobiodiversity (pages 11–12) and what policies might be used to help maintain agrobiodiversity (pages 13–16). *Crop wild relative* issue 11 also contains an outline of the dissemination tools to be used (pages 16–18), how *in situ* and *ex situ* CWR conservation activities are integrated in Spain (pages 18–20) and then how the *in situ* conserved resource might be linked to the user community (pages 22–25). Issue 11 is concluded with a review of the CAPFITOGEN toolbox, a suite of inter-related informatic tools that aim to facilitate PGR community operations and for which additional tool development is being funded by Farmer's Pride (pages 26–29).

Crop wild relative is not restricted to reporting research purely within the context of the Farmer's Pride project; we aim to incorporate news and research whether it be from within Europe or elsewhere. We therefore hope you find this issue informative and stimulating and we look forward to receiving your contributions for Issue 12 of *Crop wild relative* which is due to be published in spring 2020.

Participants at the start-up meeting of Farmer's Pride in Ancona, Italy, 11–13th December 2018.

Farmer's Pride: networking, partnerships and tools to enhance in situ conservation of European plant genetic resources

N. Maxted and S. Kell

School of Biosciences, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK. Email: n.maxted@bham.ac.uk

Agriculture is facing unprecedented challenges from a rapidly expanding human population and an unstable and changing cultivation environment (FAO, 2010). To increase food production sustainably in the face of these challenges requires multiple tools ranging from the application of novel technologies in breeding and farming to the broadening of the genetic base beyond what is currently held and available for use through *ex situ* collections (Tanksley and McCouch, 1997). Such additional diversity is available in European landrace (LR) and crop wild relative (CWR) populations held within more traditionally diverse farming systems and in nature, but its use has historically been limited both by its lack of availability and its lack of ease of use (Underhill *et al.*, 2013). As concluded in the recent Preparatory Action (Valdani Vicari & Associati *et al.*, 2016), if we are to meet these challenges then integration is critical: of formal and informal conservation sectors; of *in situ* and *ex situ* actions; of conservation with use; and of global; regional and national conservation. Historically too often the diverse communities working with plant genetic resources (PGR) (i.e. farmers, gardeners, breeders, protected area and gene bank managers, NGOs, academics, policy makers, environmentalists and consumers) have existed in parallel and in isolation. *Farmer's Pride* will build bridges between communities, integrate conservation actions while maximising use.

Most significantly *Farmer's Pride* will build on existing European and national networks to establish for the first time a network of sites and stakeholders that safeguards our wealth of *in situ* PGR. The existing networks include farmer and gardener organisations (ARCN, DSS, PSR), European plant breeders (ESA, UPV on behalf of EUCARPIA) and the European conservation network (ECPGR, NORDGEN), renowned gene banks (AARI, DIMITRA, IPK, BPGV, WUR), European plant wild species conservation networks (EUROSITE and PLANTLIFE), *in situ* conservation experts (LUKE, UOB, URJC), and on-farm conservation organic farming experts (OMKI, PSR, UNIPG), as well as PGR policy and informatics specialists (BIOVER, IPK), all are *Farmer's Pride* partners. Therefore, we will use a 'network of networks' and 'multi-actor' approach to build relationships both between existing networks and where necessary, create new partnerships, to fill the *in situ*/on-farm gap in current European PGR conservation actions.

"Our vision is to establish a European network of sites and stakeholders, where PGR flows seamlessly between farmers/site managers and germplasm users to promote sustainable agricultural, food and nutritional security, underpinning cultivar innovation, and ultimately ensuring future European consumer wellbeing."

Wild asparagus and carrot on the Lizard Peninsula, Cornwall, UK (Photo: Nigel Maxted).

Wild *Malus sylvestris* growing at Fishpond Bottom, Dorset UK (Photo: Nigel Maxted).

Farmer's Pride partners are listed in Table 1 and our objectives to be achieved within the three-year project lifetime:
Table 1. *Farmer's Pride* partners.

Participant No (Person)	Participant organisation name	Country
1 (Maxted/Kell)	University of Birmingham (UOB)	UK
2 (Drucker/Dulloo)	Bioversity International (BIOVER)	IT
3 (Negri/Raggi)	Universita Degli Studi Di Perugia (UNIPG)	IT
4 (Palmé/Carlson-Nilsson)	Nordic Genetic Resource Centre (NORDGEN)	SE
5 (Iriondo/Rubio Teso)	Universidad Rey Juan Carlos (URJC)	ES
6 (Bartha)	Pro Species Rara network (PSR)	CH
7 (van Hintum)	Wageningen UR (WUR)	NL
8 (Civic/Brandehof)	Eurosite network (EUROSITE)	NL
9 (Drexler/Fehér)	Hungarian Research Institute of Organic Agriculture (ÖMKi)	HU
10 (Weise/Kreide)	Leibniz Institute of PG and CP Research (IPK)	DE
11 (Aykas/Özpinar)	Aegean Agricultural Research Institute (AARI)	TU
12 (Heinonen)	Natural Resources Institute Finland (LUKE)	FI
13 (Barata/Magos Brehm)	Portuguese National Genebank (BPGV)	PT
14 (Ralli)	Hellenic Agricultural Organization (DIMITRA)	GR
15 (Poulsen)	Danish Seed Savers (DSS)	DK
16 (Kajtna/Maierhofer)	Arche Noah – seed savers in Central Europe (ARCN)	AT
17 (Prohens)	Polytechnic University of Valencia (UPV)	ES
18 (Hawley/Inwood)	Plantlife network (PLANTLIFE)	UK
19 (Csörgő)	European Seed Association (ESA)	BE

1. Establish PGR stakeholders, status and network best practice

Build on recent knowledge of European LR and CWR genetic diversity gained from previous EC funded projects (PGR Forum, AEGRO, SOLIBAM, PGR SECURE, DIVERSIFOOD and the Preparatory Action) to develop an understanding of stakeholders involved in PGR conservation and use, patterns of LR and CWR genetic diversity across Europe and exemplars of how that diversity might be collectively managed.

- Prepare a comprehensive statement of stakeholders involved in European PGR conservation and use;
- Review existing knowledge of CWR genetic diversity (>5,000) and collate knowledge of LR diversity (>1,500) held on-farm and in-garden across Europe;
- Review diverse approaches to multi-site collective PGR management and 'showcase' options for networking best practice.

Goal: sound knowledge of European PGR diversity as a basis for in situ *and on-farm (with backup* ex situ*) conservation. 50 sites identified for active on-farm conservation of diverse LR and 50 sites identified for active* in situ *conservation of diverse CWR, with recommendations for* ex situ *genebank holdings. Sites and populations form the baseline for future network monitoring.*

2. Enhance PGR population management and best practice

Build on recent insight of European LR and CWR population management gained from previous EC funded projects (*idem*) to develop an understanding of how that population level diversity might be most effectively managed, secured and made available to diverse user stakeholders.

- Review diverse approaches to PGR population management, establish standards and 'showcase' options for best practice;
- Describe a means of integrating formal and informal 'community-based' approaches to PGR population management;
- Develop practical field and informatic tools that help promote PGR population management;
- Facilitate the links between *in situ* and *ex situ* conservation, so promoting access of *in situ* conserved PGR to diverse users, particularly farmers, growers and breeders.

Goal: comprehensive understanding of diverse approaches to PGR population management and provision of a web-enabled evidence-base to underpin sustainability and enhancement of PGR maintenance systems. Web-enabled evidence-base with over 100 examples of LR and CWR population maintenance, 100 farmers and 5–10 SMEs show direct benefits.

3. Promote PGR *in situ* valuation and use

Use social science and economic tools to establish farmer preferences/values for LR and the public's willingness to pay for conservation (which is a measure of the benefits that society places on LR/CWR conservation), to facilitate the seamless flow of PGR from the *in situ* resources to various user communities.

- Review present conservation and sustainable PGR use incentives that help sustain the resource;
- Elaborate policy recommendations for cost-effective conservation strategies for populations and individual traits;
- Review policy and strategic action plan with recommendations on how existing level of LR and CWR conservation and use support mechanism might be enhanced.

Goal: wide-ranging understanding of the economic and social dynamics of PGR management and public willingness to fund PGR conservation, policy recommendations for enhancements that promote the sustainability of PGR conservation and use.

4. Establish durable PGR network partnerships

Starting from existing networks, build an integrated, self-sustaining network of networks to conserve: (a) crop LR on-farm, (b) LR in-garden, and (c) CWR in genetic reserves or less formal *in situ* sites.

- Develop and establish a durable governance, functional and resourcing structure for European *in situ* PGR conservation that address the needs of farmers, gardeners, breeders, protected area and genebank managers, academics, policy makers and ecosystem conservationists and that delivers European food and nutritional security;
- Develop and establish durable *in situ* PGR conservation structures that integrates European and national actions and promotes formal/informal sector interactions to underpin food and nutritional security;

Plots of Bere barley accessions grown for phenotypic characterisation, Orkney, Scotland (Photo: Nigel Maxted)

Orkney Bere beer and whisky, adding value to Bere barley landrace production, Orkney, Scotland (Photo: Nigel Maxted)

- Bring together all PGR stakeholders involved in PGR conservation and sustainable use to meet the changing demands of European consumers;
- Maximize *in situ* PGR conservation of LR and CWR genetic diversity in Europe.

Goal: Establish a network of stakeholders and sites for in situ *PGR conservation of LR and CWR genetic diversity across Europe. At least three sites identified in each of 20 European countries join the nascent European Agrobiodiversity* In Situ *Conservation Network.*

5. Promote PGR awareness and *Farmer's Pride* product/ tool dissemination

Promote awareness of the actual and potential value of PGR, the breadth of diversity found *in situ* and the responses that may be found from its sustainable use to some of the challenges linked to food and nutritional security. Publicise the *Farmer's Pride* project and products to the multi-sector stakeholder community.

- Hold a final dissemination conference to showcase *Farmer's Pride* results and launch the European PGR network to a wide international (European and non-European) audience;
- Raise awareness of PGR uniqueness and value amongst PGR maintainers, managers, user communities and policy makers through website, social networking media, newsletters, best practice case studies, advocacy plans, publications, and dissemination events;
- Disseminate *Farmer's Pride* products to diverse users, maintainers and managers, the plant breeding and PGRFA conservation communities, national and European policy-makers and the European Commission and promote their use to benefit sustainable agriculture and food security.

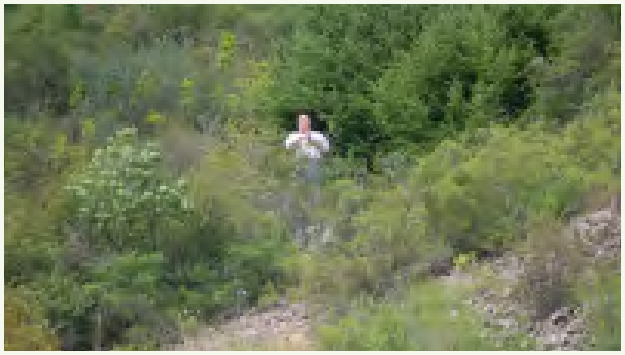
Goal: ensure Farmer's Pride products are disseminated via the project website, FP Ambassadors[1], dissemination conference and multimedia events to reach potential stakeholder communities and European consumers, thus fulfilling their potential to enhance and maintain European PGR diversity for future generations.

To achieve these goals, Farmer's Pride work programme is divided into six workpackages: the first four research WPs cover the establishment of new partnerships and tools to enhance European *in situ* PGRFA conservation and use capacity, while WP5 focuses on promotion of the new partnerships and dissemination of networking tools/products, and WP6 focuses on project management. The first four research WPs are reported in Table 2 and the basic methodology in Figure 1.

1 Volunteers working with *Farmer's Pride* to collate data, discuss tasks and disseminate output.

Table 2. Farmer's Pride workpackages, tasks and exploitation measures to ensure impact

WP	Task	Potential user communities					
		Farmer/ gardener	Breeder	PGR conservation	Environment conservation	Policy maker	Consumer
1: Networking Options	1.1 Identify *in situ* stakeholders	–	–	√	√	√	√
	1.1 Knowledge of *in situ* resources	√	√	√	√	√	√
	1.3 LR hotspots identification	√	√	√	√	√	√
	1.4 LR Network Showcase	√	√	√	√	√	–
	1.5 CWR Network Showcase	√	√	√	√	√	–
2: Population Management	2.1 LR population management	√	–	√	–	√	–
	2.2 Community seedbank management	√	–	√	–	√	–
	2.3 CWR population management	–	–	√	√	√	–
	2.4 Informatic tools	√	√	√	√	√	–
	2.5 Facilitating *in situ* conserved use	√	√	√	√	√	–
	2.6 Integrated *in situ* and *ex situ* con.	–	–	√	√	√	–
3: Enabling Use & Conservation	3.1 Incentives for conservation/use	√	√	√	√	√	–
	3.2 ID useful *in situ* traits	√	√	√	–	√	–
	3.3 Enhancing *in situ* conserved use	√	√	√	√	√	–
	3.4 Public willingness to fund PGR	–	–	√	√	√	√
	3.5 Policy dialogues	√	√	√	√	√	√
4: Network Design & Implementation	4.1 Integrated network structures	√	√	√	√	√	–
	4.2 LR network design	–	–	√	√	–	–
	4.3 CWR network design	–	–	√	√	–	–
	4.4 Integrated network implementation	√	√	√	√	√	√



Collecting wild chickpeas in Georgia (Photo: Nigel Maxted)

Santorini landrace tomato (Photo: Nigel Maxted)

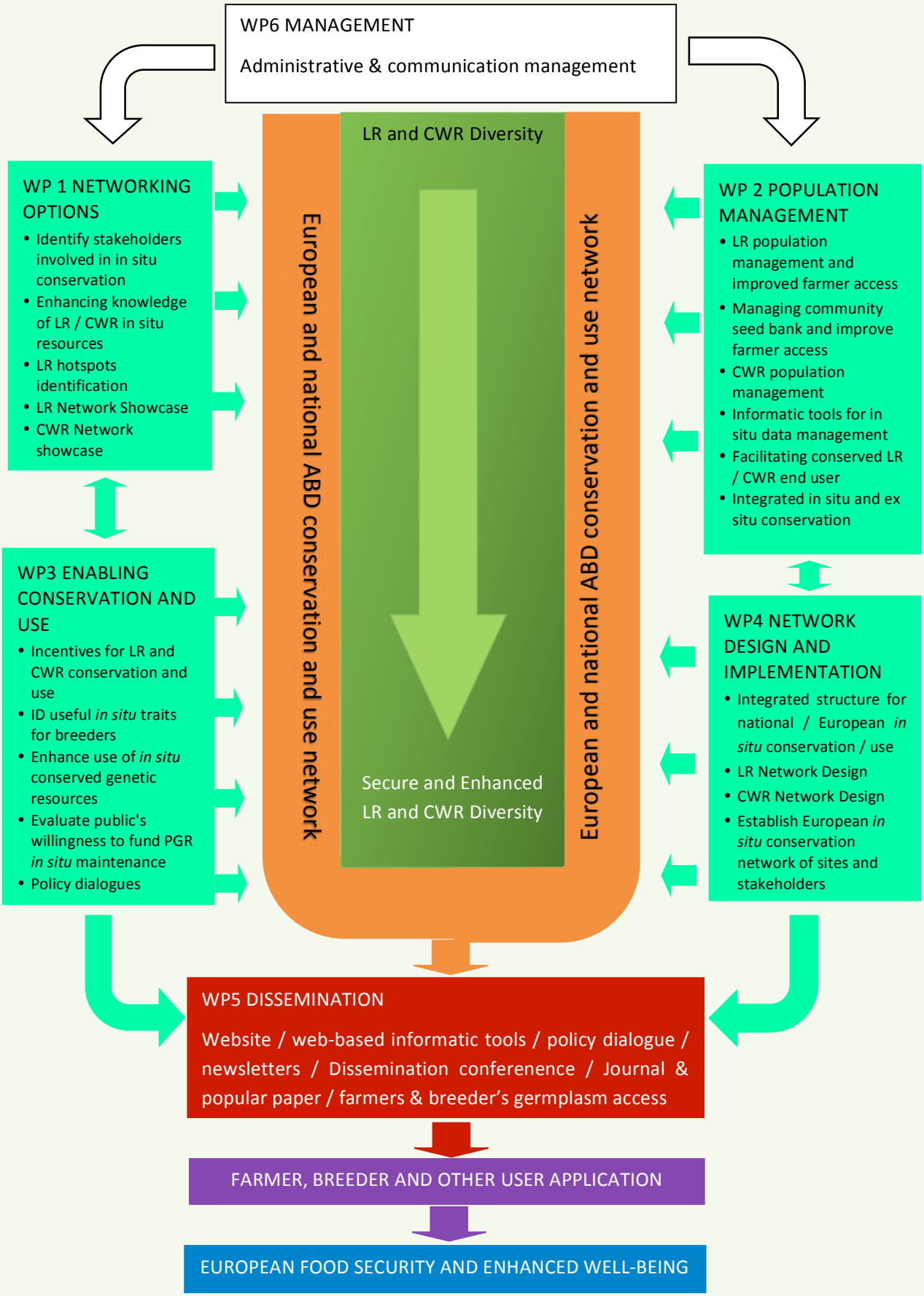


Figure 1. Farmer's Pride overall methodology.

Farmer's Pride overall project concept

Although historically PGR conservation has almost exclusively been focused on seed collection and gene bank *ex situ* storage, in recent years significant progress has been made in developing and testing *in situ* methodologies for both LR (Veteläinen *et al.*, 2009) and CWR (Iriondo *et al.*, 2008; Hunter and Heywood 2010; Maxted *et al.* 2012) conservation, which for the first time permit true complementary conservation using *in situ* and *ex situ* techniques to conserve the breadth of PGR diversity in Europe. Further, within Europe recently blueprints for *in situ* PGR conservation have been proposed via the ECPGR *In Situ* (Maxted et al., 2005) and On-farm Concepts (ECPGR, 2017), which outline how a self-sustaining network that fully integrates both national and regional level (linked to global) *in situ* PGR conservation and use could be achieved (Figure 2).

The proposed structure for the integrated European PGR *in situ* network would be developed via two interrelated geographic or more precisely geopolitical levels of conservation strategy planning: national (Figure 2 light green) and (ii) European (Figure 2 blue), which integrated together form the integrated regional conservation strategy for Europe (Figure 2 orange). National implementation will be at the core of Network establishment, therefore whether a site provides national only, or national and regional *in situ* conservation, its inclusion is justified by it containing significant PGR populations that have respective national or regional value. However, only national authorities can formally nominate sites for inclusion in the network, so maintaining sovereignty over national genetic resources. Also, practical management and monitoring would necessarily be implemented at national level, though potentially with European tool and resource support.

The integrated European PGR *in situ* network would be driven by regional and national policy on PGR conservation and utilization (Figure 2 red) and implemented at national level (Figure 2 light green). The cyclical flow of the two related European and national PGR conservation strategies in Figure 2, indicating repeated cycles of planning and implementing *in situ* PGR conservation underlines the point that it is an iterative process requiring periodic review and updating as PGR conservation and utilisation policy, science and practice develops. The purpose of the integrated strategy is to preserve PGR for use in crop improvement and so maintain cultivar development options, particularly critical to address climate change and human population growth. Therefore, making *in situ* conserved PGR available to farmers and breeders (Figure 2 purple) is a fundamental to network success, but raising awareness of the value of PGR to food and economic security will help ensure the long-term *in situ* PGR resource.

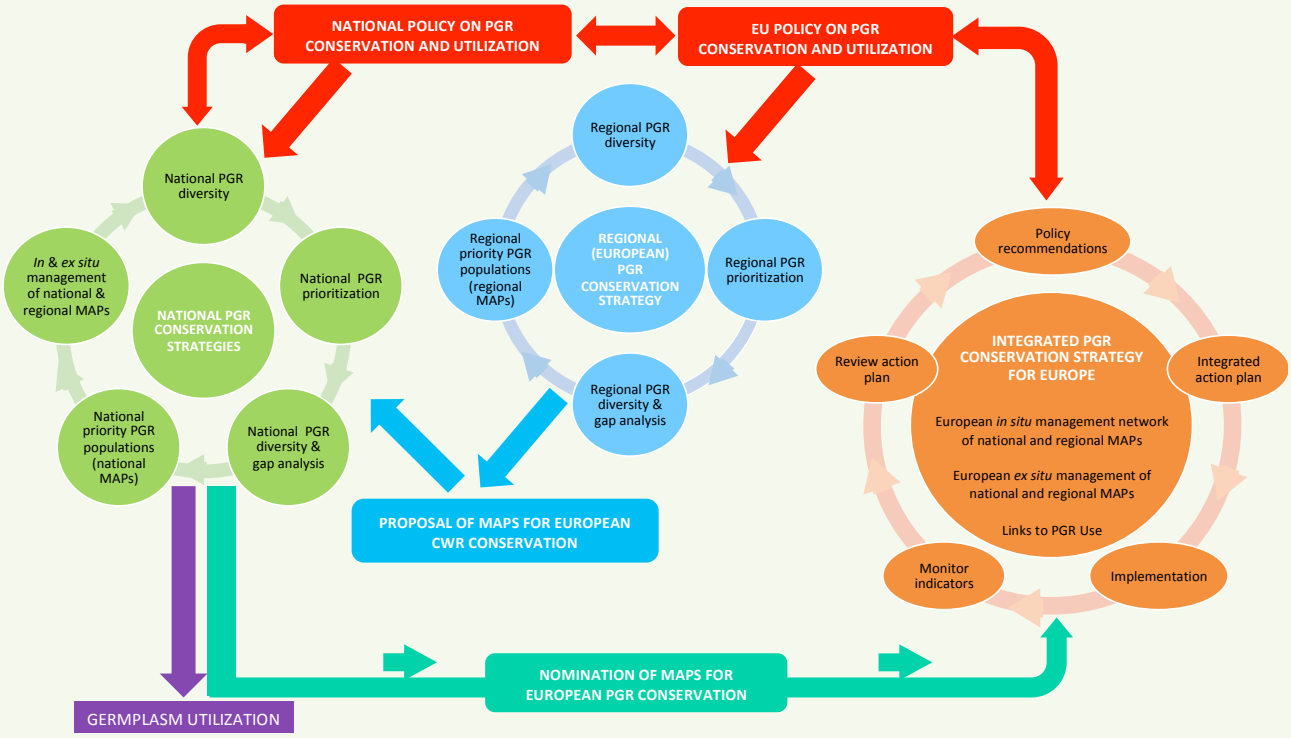


Figure 2. Schematic representation of the structure of integrated European PGR *in situ* network (Maxted *et al.*, 2013).

The expected impacts of Farmer's Pride will be to:

- Identify the breadth and range of *in situ* (including on-farm and in-garden) conservation sites and stakeholders, and the trait diversity found *in situ*;

- Build a self-sustaining network of *in situ* sites/populations and stakeholders involved in PGR conservation and sustainable use through which germplasm flow is significantly improved from source to end user. The durability of the *in situ* network structure established will be underpinned by showcases of good practice and illustrated by the mutual benefit derived by diverse stakeholder's involvement in the network;

- Use the blueprint proposed in the ECPGR *In Situ* and On-farm Concepts to provide a self-sustaining network structure that fully integrates national and regional in Europe (with even future global) *in situ* PGR conservation and use;

- Enhance the link between *in situ* and *ex situ* conservation to (i) provide a back-up of *in situ* conserved populations and (ii) facilitate breeder/farmer access to the *in situ* conserved resource;

- Collate information on the value and importance of PGR (maintaining the breadth and depth of LR and CWR diversity) as one element of sustaining agriculture production, and so food security and consumer choice for the general public. Diverse printed and digital media will be used as awareness raising tools, specifically tailored to meet the knowledge base of policy makers, farmers and consumers;

- Address the need to link *in situ* PGR conservation to use by promoting (i) improved farmer/gardener access to PGR diversity, (ii) improved breeder access to *in situ* PGR diversity, (iii) integrated *in situ* with *ex situ* conservation, (iv) product value chain enhancement; and

- Contribute to farming and breeder competitiveness, foster healthy diets and encourage food diversity by (i) maximizing PGR actively conserved *in situ*, (ii) ensuring the seamless flow of PGR from *in situ* source to farmers and breeders, (iii) providing an evidence-based platform of best practice for food quality and product value enhancement, and (iv) raising awareness among policy makers, farmers and consumers of the value of healthy diets and food diversity.

Finally, by establishing true complementary CWR and LR diversity conservation for the first time in Europe it can be argued that the implementation of *in situ* network will in time at least double the PGR diversity available to breeders, and that would be a significant achievement.

For further information, please visit the project website: www.farmerspride.eu or contact the project's Coordination Team: n.maxted@bham.ac.uk or s.kell@bham.ac.uk

References

ECPGR, (2012). *Report of the 13th ECPGR Steering Committee Meeting* was held at the Federal Ministry of Agriculture, Forestry, Environment and Water Management Austria on 4–7 December 2012. European Cooperative Programme for Plant Genetic Resources, Rome, Italy.

ECPGR, (2017). *ECPGR concept for on-farm conservation and management of plant genetic resources for food and agriculture*. European Cooperative Programme for Plant Genetic Resources, Rome, Italy.

FAO, (2013). *Towards the establishment of a global network for* in situ *conservation and on-farm management of PGRFA*. Report of Technical Workshop held in Rome, Italy 13/11/12. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO, (2010). *The Second Report on the State of the World's Plant Genetic Resources*. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO, (2011) *Thirteenth Regular Session of the Commission on the Genetic Resources for Food and Agriculture, CGRFA-13/11/Report*. Food and Agriculture Organization of the United Nations, Rome, Italy.

Hunter, D. and Heywood V.H., (2010). *Crop wild relatives: a manual of* in situ *conservation*. Earthscan, London.

Iriondo, J.M., Maxted, N. and Dulloo, E. (eds.), (2008). *Conserving plant genetic diversity in protected areas: population management of crop wild relatives*. CAB International, Wallingford.

Maxted, N., Dulloo, M.E., Ford-Lloyd, B.V., Frese, L., Iriondo, J.M. and Pinheiro de Carvalho, M.A.A., (eds.), (2012). *Agrobiodiversity conservation: securing the diversity of crop wild relatives and landraces*. CAB International, Wallingford.

Maxted, N., Avagyan, A. Frese, L., Iriondo, J.M., Magos Brehm, J., Singer, A. and Kell, S.P. (2015). *Preserving diversity: a concept for in situ conservation of crop wild relatives in Europe Version 2*. Rome, Italy: *In Situ* and On-farm Conservation Network, European Cooperative Programme for Plant Genetic Resources, Rome, Italy. http://www.ecpgr.cgiar.org/fileadmin/templates/ecpgr.org/upload/WG_UPLOADS_PHASE_IX/WILD_SPECIES/Concept_for_in_situ_conservation_of_CWR_in_Europe.pdf

Tanksley, S.D. and McCouch, S.R., (1997). Seed Banks and Molecular Maps: Unlocking Genetic Potential from the Wild. *Science*, 277, 1063–1066.

Underwood, E., Poláková, J., Berman, S., Dooley, E., Frelih-Larsen, A., Kretschmer, B., Maxted, N., McConville, A.J., Naumann, S., Sarteel, M. and Tostivint, C., (2013). *Technology options for feeding 10 billion people. Synthesis report Options for sustainable food and agriculture in the EU*. STOA, European Parliament, Brussels.

Valdani Vicari & Associati, Arcadia International, Wageningen UR: Centre for Genetic Resource, the Netherlands, Plant Research, International (PRI) and the Socio-economics Research Institute, Fungal Biodiversity Centre of the Royal Academy of Arts and Science, Information and Coordination Centre for Biological Diversity of the German Federal Office for Agriculture and Food, (2016). *Preparatory action on EU plant and animal genetic resources - Final Report*. European Commission Directorate-General for Agriculture and Rural Development, Brussels, Belgium.

Not just pandas and elephants: agrobiodiversity needs conservation incentives too

Adam G. Drucker
Alliance of Bioversity International and CIAT, Rome, Italy. Email: a.drucker@cgiar.org

An unprecedented and irreversible loss of agrobiodiversity (ABD)[1] is occurring at the ecosystem, species and genetic levels throughout the world, with threats to diversity getting stronger[2]&[3]&[4] A fundamental conundrum is thus experienced in most countries today: how to safeguard the biodiversity maintained in the fields of the rural poor – which constitutes a national and global good for maintaining future options, food security and ecosystem health – whilst meeting those same people's development needs and rights?

From an economics perspective, this challenge is related to overcoming a series of market, intervention and global appropriation failures[5]&[6]&[7]. A number of these are associated with the existence of a range of (local, national and global) public good ecosystem services generated by *in situ* on-farm agrobiodiversity management. These include risk management, ecological stability and resilience at the landscape level[8]&[9]&[10]&[11], maintaining cultural traditions (including food culture), local identities and traditional knowledge[12], as well as the maintenance of evolutionary processes, gene flow and global option values.[13]

The existence of such significant non-market and/or public good values, an overestimation of the performance of improved plant and animal genetic resources (PAGR) under less than ideal production system conditions and important intervention failures (e.g. subsidies that favour improved variety/breed PAGR production) provide a strong justification for intervention in order to ensure that that farmers undertaking *de facto* conservation are not expected to shoulder the burden of maintaining socially-desirable levels of PAGR for the national and global public good by themselves.

In other contexts where important public good ecosystem service values exist, such as in the case of forests, water, wild biodiversity and landscape aesthetics, Payments for Ecosystem Services (PES) have been widely applied as incentive mechanisms to motivate natural resource conservation. Worldwide there are now over 550 active PES programmes, with estimated transactions of US$36–42 billion p.a. (see recent reviews[14]&[15]&[16]). However, just 2% were focussed on biodiversity conservation in general[17]. The need to intervene to ensure that agricultural biodiversity *per se* is maintained has received even less attention. A rare exception is EU support payments for threatened livestock breeds under Regulations 1257/99 and 1750/99.

While no similar support for plant genetic resources currently exists, the application of PES concepts in the context of high public good value agrobiodiversity under threat has been shown elsewhere to be promising[18] across a range of crops in providing a cost-effective incentive mechanism for meeting national legislative and international commitments. A first ever crop wild relative (CWR) application also took place recently in Zambia (see https://tinyurl.com/CWR-Economics-Zambia). This revealed that farmers do recognise, manage and are willing to engage in CWR conservation activities (particularly in their field borders) at modest cost. [19] The research and development platform underlying such Payments for Agrobiodiversity Conservation Services (PACS) approaches also brings together many different kinds of partners in a platform where they can collectively learn more about conserving and using their shared agrobiodiversity, for example with regard to prioritising, setting conservation targets, designing cost-effective interventions and implementing farmers' rights.

It is within this broader context that the socio-economics work being carried out in the Farmer's Pride project seeks to contribute to an improved enabling environment for the conservation and sustainable use of landraces (LR) and CWR in the EU. The existing **incentives for conservation/use** framework is being explored through an assessment in selected countries of the costs, benefits and impacts of the EU's Rural Development Plans and other schemes for incentivising the conservation and use of LR and CWR diversity. Together with a survey (currently ongoing) in Austria, Greece and the UK of farmers' willingness to participate in conservation activities, this will allow policy recommendations to be identified related to how existing levels of LR and CWR conservation and use funding could be adapted to achieve more effective outcomes.

With a view to determining **public willingness to fund PGR conservation and use,** an assessment is being carried out of the market and non-market values the general public associates with agrobiodiverse-related goods and ecosystem services (such as their socio-cultural, landscape resilience/maintenance and future option values). To date, 680 willingness-to-pay surveys have been applied across five countries (Austria, Greece, Hungary, Switzerland and UK), with approximately 120 more to be completed. Findings will be used to orient overall conservation policy and strategic action plans, as well as support the design of cost-effective conservation initiatives and incentive mechanisms.

Zambia Crop Wild Relatives Identification and Conservation Capacity Building Farmer Workshop (Photo: Wainwright)

1 Biodiversity for food and agriculture or "agrobiodiversity" is a subcategory of biodiversity that corresponds to "the variety and variability of animals, plants and micro-organisms at the genetic, species and ecosystem levels that sustain the ecosystem structures, functions and processes in and around production systems, and that provide food and non-food agricultural products"1.

2 FAO. 2019. The State of the World's Biodiversity for Food and Agriculture.

3 FAO. 2015. State of the World's Animal Genetic Resources. FAO

4 FAO. 2010, State of the World's Plant Genetic Resources. FAO

5 Narloch, U., Pascual, U. and Drucker A.G. 2013. How to achieve fairness in payments for ecosystem services? Insights from agrobiodiversity conservation auctions. Land Use Policy 35:107-118.

6 Pascual, U. and Perrings, C. 2007. The economics of biodiversity loss in agricultural landscapes. Agricultural Ecosystem Environment 121, 256-268.

7 Heisey, P.W., Smale, M., Byerlee, D., Souza, E. 1997. Wheat rusts and the costs of genetic diversity in the Punjab of Pakistan. American Journal of Agricultural Economics 79: 726-737.

8 Baumgärtner, S., 2008. Why the measurement of species diversity requires prior values judgements. In: Kontoleon, A., Pascual, U., Swanson, T. (Eds.), Biodiversity Economics: Principles. Cambridge University Press, UK, Methods and Applications, pp. 293–310.

9 Di Falco, S., Chavas, J.P., 2009. On crop biodiversity, risk exposure and food security in the highlands of Ethiopia. American Journal of Agricultural Economics 91 (3), 599-611.

10 Hajjar, R., Jarvis, D.I., Gemmill-Herren, B., 2008. The utility of crop genetic diversity in maintaining ecosystem services. Agriculture, Ecosystems and Environment 123, 261–270.

11 Heisey, P.W., Smale, M., Byerlee, D., Souza, E. 1997. Wheat rusts and the costs of genetic diversity in the Punjab of Pakistan. American Journal of Agricultural Economics 79: 726-737.

12 Nautiyal, S., Bisht, V., Rao, K.S., Maikhuri, R.K., 2008. The Role of cultural values in agrobiodiversity conservation: a case study from Uttarakhand, Himalaya. Journal of Human Ecology 23 (1), 1–6.

13 Bellon, M. R. 2009. Do we need crop landraces for the future? Realizing the global option value of in situ conservation. Pages 51-59. In A. Kontoleon, U. Pascual and M. Smale (eds,) Agrobiodiversity and Economic Development. London and New York: Routledge

14 Börner, J., Baylis, K., Corbera, E., Ezzine-de-Blas, D., Honey-Rose, J., Martin Persson, U. and Wunder, S. 2017. The Effectiveness of Payments for Environmental Services, World Development 96: 359-374; , http://dx.doi.org/10.1016/j.worlddev.2017.03.020

15 Wunder, S., Brouwer, R., Engel, S., Ezzine de Blas, D., Muradian, R., Pascual, U., Pinto, R. 2018. From principles to practice in paying for nature's services. Nature Sustainability 1(3): 145–150

16 Salzman, J., Bennett, G., Carroll, N., Goldstein, A. and Jenkins, M. 2018. The global status and trends of Payments for Ecosystem Services Nature Sustainability 1: 136–144.

17 Grima, N., Singh, S.J., Smetschka, B. and Ringhofer, L. 2016. Payment for Ecosystem Services (PES) in Latin America: Analysing the performance of 40 case studies. Ecosystem Services 17: 24-32.

18 Drucker, A.G., Ramirez, M. and Medina, T. 2017. Incentivos costo-efectivos para la conservación y uso in situ/en chacra de la agrobiodiversidad: avances en el programa ReSCA en América Latina. Simposio Internacional de Recursos Genéticos para América Latina y el Caribe (SIRGEALC), October. Guadalajara, Mexico

19 Wainwright, W., Drucker, A.G., Maxted, M., Brehm, J.M., Ng'uni, D. and Moran, D. 2019. Estimating in situ conservation costs of Zambian Crop Wild Relatives under alternative conservation goals. Land Use Policy (81) 632-643.

Enabling the establishment of a European network for *in situ* conservation of PGRFA.

Ehsan Dulloo

"Our future food security depends on the survival of a wide range of plant genetic resources, including wild relatives of crops and locally-adapted cultivated varieties (landraces)"

Farmer's pride Policy Brief no.1 (2019)

Introduction

Uninsured economic losses to the EU agricultural sector due to extreme weather events brought about by climate change have been estimated at as much as €13 billion p.a.[20] because of insufficient diversity in our crops. The future of a strong agricultural economy in Europe is dependent on crops that can, not only thrive in the increasingly extreme and uncertain environmental conditions resulting from climate change, but that are also adapted to environmentally friendly agriculture, meet the needs of an expanding population and diverse consumer demands.

A wide variety of plant genetic resources for food and agriculture (PGRFA) is the basis of food and nutrition security, as well as the foundation of economic security in the agricultural sector – yet mainstream agriculture currently relies on limited diversity, both in terms of the number of crop species cultivated and the diversity within those crops. Critically, there is an urgent need to promote the *in situ* (on-site) conservation of crop landraces (traditional local varieties) and wild species related to crops, which are rich pools of genetic diversity of potential value for crop improvement, as well as landraces themselves being of direct and significant value for local food systems and economic security. Currently, conservation efforts are largely *ad hoc*, uncoordinated and insufficiently resourced throughout the region, despite extensive evidence of ongoing threats to these resources and a resultant loss of diversity.

The EU Horizon 2020 Farmer's Pride project is establishing a European network for *in situ* conservation and sustainable use of plant genetic resources – an action that is critical for future food, nutrition and economic security in the region. Its successful establishment and future sustainability will depend on the appropriate political enabling environment and governance structure, with associated long-term resources, to be in place.

Key challenges

There are a number of key challenges that are limiting the systematic conservation and sustainable use of PGRFA in Europe that require responses at policy level. In summary these are:

The divergence of PGRFA stakeholder communities: A lack of common engagement among the diverse stakeholder communities, particularly between the agriculture and environment sectors, has led to divergent and conflicting policies, which are hampering efforts to conserve and use PGRFA. Bridging the 'gaps' between the divergent interests and views of these communities requires a review and harmonisation of the relevant policies dealing with food, agriculture, biodiversity and the environment.

No clarity regarding possible access and benefit-sharing (ABS) rules with regard to genetic resources conserved in situ: Ensuring the use of PGRFA diversity in situ is the only long-term guarantee of its maintenance, yet access and benefit-sharing is complicated because in contrast with plant diversity conserved *ex situ*, PGRFA *in situ* are by nature widely dispersed in many locations and managed by a broad range of stakeholders. There is therefore a critical requirement to create a policy environment in which access, use and benefit-sharing regarding *in situ* conserved PGRFA is facilitated.

Insufficient characterisation and evaluation: For PGRFA diversity to be of use to plant breeders and farmers, a process involving the identification of useful traits (characterisation) and subsequent evaluation of plant material to confirm its potential and to select the best individuals to use in crop improvement programmes by farmers and breeders is essential. Contemporary genomic approaches and so-called 'predictive characterisation' techniques can be used, inter alia, to identify the most promising PGRFA populations, both wild and cultivated and both *in* and *ex situ*. However, lack of resources is severely hampering these efforts.

Adaptation of variety registration rules to specific types of varieties/material: In the EU, strict rules on variety registration and seed certification have been in place since the 1960s. They aim to provide transparency in the market, ensure the availability of quality seeds and information about crop varieties for farmers, and to create a level playing field for the industry. In order to adapt this legislative framework to the changing conditions and needs, the EU adopted two directives[21] that aim to support the conservation of landraces by providing the option for farmers to register and market their crops as "conservation or "amateur" varieties. However, these directives appear to have had little positive impact in practice and therefore might need to be reviewed. The recently adopted EU regulation on organic production allows for the marketing of organic heterogeneous material according to the rules that are still to be specified,[22] and could help to facilitate the continued cultivation of landraces.

However, it will likely be many years before the effects of such legislation are understood.

Lack of *in situ* conservation incentive mechanisms*:* As many of the benefits of PGRFA management are public goods – inter alia, contributing to resilience at the landscape level in the context of climate change, maintaining traditional knowledge/ cultural practices (including food culture) that benefit European and global society in general – markets alone cannot be expected to reward farmers adequately for managing socially desirable levels of diversity. Current incentive mechanism schemes, where they exist at all, are *ad hoc* and uncoordinated, raising issues related to the extent to which such schemes do in fact take a strategic approach to supporting threatened LR and CWR (given that not everything can be conserved), as well as their impact on the risk status of such crop populations and the degree to which farmers are ultimately able to capture some of the benefits of providing a public good PGRFA conservation service. Improved policy instruments are needed to ensure that support mechanisms can more effectively achieve conservation outcomes and benefit sharing goals.

Lack of an existing PGRFA *in situ* network: In stark contrast with the extensive, existing infrastructure for *ex situ* conservation of PGRFA in gene banks associated with ECPGR[23] and wild plant conservation *in situ* overseen by DG Environment (the Natura 2000 Network), there is no provision for *in situ* conservation of PGRFA in Europe. This is despite the need for the establishment of an *in situ* network for CWR and LR conservation having been recognised by the FAO CGRFA[24], the Governing Body of the ITPGRFA[25], CBD secretariat[26] and specifically in Europe by the Directorate General for Agriculture and by the European Parliament. There is therefore a critical need for policy to backstop the establishment and governance of a network for PGRFA conservation and sustainable use in Europe.

Inadequate informatics infrastructure: An essential element of the network is an informatics infrastructure that facilitates the functioning of the network as a whole and individual site management, as well as acting as a medium for stakeholder communication and collaboration. Policy to support the conservation and sustainable use of PGRFA *in situ* therefore needs to make provision for the development and long-term management of a suitable platform and user interface, as has similarly been developed and implemented for PGRFA in gene banks (EURISCO) under the umbrella of the ECPGR.

The current policy environment for *in situ* conservation and sustainable use of PGRFA

At global level

There are a number of international agreements, action plans and policy instruments that are relevant to the conservation and sustainable use of PGRFA:

- The 1992 Convention on Biological Diversity (CBD) and the associated 2010 Strategic Plan for Biodiversity 2011–2020 and 2014 Nagoya Protocol. The CBD recognises *in situ* conservation as the primary means of conserving biodiversity and Aichi Biodiversity Target 13 specifically calls for development and implementation of strategies for the maintenance of the genetic diversity and minimising genetic erosion of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species. Aichi Target 3 calls for the elimination of disincentives and for the development of positive incentives for conservation and use.
- The 2001 International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) highlights the critical need for *in situ* conservation of PGRFA, particularly through the provisions in Art. 5 (Conservation), Art. 6 (Sustainable use) and Art. 9 (Farmers Rights) as well as provisions creating its Multilateral System of Access and Benefit-Sharing.
- The FAO 2011 Second Global Plan of Action for PGRFA (GPA) defines 18 Priority Activities, of which the first four relate to the *in situ* conservation and management of PGRFA.
- The UN Sustainable Development Goals (SDGs). SDG Goal 2 highlights the need for eradicating extreme poverty and hunger and its target 2.5 requires the maintenance of the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species.
- The FAO 2015 Voluntary Guide for National Seed Policy Formulation highlights potential key elements of national seed policies promoting agricultural biodiversity.

At European level

In addition to being party to the above international agreements, EU and non-EU European countries have developed a number of regional legal and policy instruments that are relevant by varying degrees to the conservation and sustainable use of PGRFA:

- EU Biodiversity Strategy to 2020
- Habitats Directive 92/43
- EU Common Agricultural Policy (CAP) (Regulation 1305/2013)
- The community programme on the conservation, characterization, evaluation and use of genetic resources in agriculture, based on Council Regulation (EC) 870/2004 replaced by EU Research and innovation programme
- Various directives[27] aiming to enhance *in situ* conservation and use of landraces and local varieties by facilitating access to markets
- EU Regulation 511/2014 (EU ABS Regulation)
- ECPGR Concepts for *in situ* conservation of CWR and LR.[28]

Despite the above legal instruments to which EU member states are party and policy instruments to which both EU Member States and other European countries are party, at the sub-regional and national levels there are very varied patterns of implementation. For example, there are differences in how the EU directives on conservation and amateur varieties have been implemented at national level. Also, not all countries[29] have identified lists of varieties under threat of genetic erosion that are eligible for

on-farm conservation to be subsidised under Article 28 of the CAP. Notably, Armenia, Azerbaijan, Belgium, France, Georgia, Greece, Germany, Italy, Netherlands, Romania, Sweden, Turkey and the UK have implemented a variety of on-farm conservation projects. However, there are no known comparable actions to promote CWR *in situ* conservation in Europe that are fully endorsed by national or regional authorities (ECPGR, 2017).

Policy advocacy

The Farmer's Pride project is a critical steppingstone for the development of a European network for conservation and sustainable use of PGRFA. As mentioned earlier, its successful establishment and future sustainability will depend on the appropriate political enabling environment to be in place. For this to happen, Farmer's Pride partners have been engaging with policy makers at different levels to raise their awareness for the *in situ* conservation and use of the plant genetic resources for food and agriculture and lobby them to endorse and support the establishment of European network for conservation and sustainable use of PGRFA.

The project prepared a policy brief (see http://www.farmerspride.eu/) that can be used by the Farmer's Pride consortium members and ambassadors to reach out to policymakers to work with Farmer's Pride and the wider stakeholder community to ensure adequate policies are in place for *in situ* conservation and sustainable use of plant genetic resources in Europe so as to safeguard the future of the agricultural economy and food and nutrition security. The brief proposed some key recommendations for policy makers to take forward:

- Take actions aimed at bridging existing policy gaps and harmonizing conflicting policies.
- Create a regulatory framework that facilitates access, use, and equitable benefit-sharing of agricultural plant diversity conserved *in situ*.
- Develop incentive mechanisms and schemes aimed at sustaining *in situ* conservation.
- Take measures required for the sustainable functioning of the 'European Network for *In Situ* Conservation and Sustainable Use of Plant Genetic Resources' established by the project.
- Support an information technology support framework (platform development, user interface) for *in situ* conservation, equal to that of the IT network for managing agricultural plant diversity in genebanks, the European Search Catalogue for Plant Genetic Resources (EURISCO).

Further the project established a Policy task force including key Farmer's Pride partners and ambassadors to identify key policy-makers in Europe with whom we should be engaging and help prepare advocacy plans for specific stakeholder groups to ensure uptake of the project outputs.

Targeted advocacy activities have been carried out throughout the project at regional, national and European levels. Many of the communication and dissemination activities referred to in this report (including partners' attendance at meetings, workshops and conferences) serve as channels for advocacy with our key stakeholder groups. The Farmer's Pride ambassadors and project partners are also promoting the project and making the case for the new European Network for *in situ* PGR conservation and sustainable use among their networks and with government departments and statutory agencies. A specific example of one such targeted advocacy meeting was organised by UOB. In December 2018, UOB and EUROSITE met the Head of the Nature Protection Unit in the EC DG Environment Dir D – Natural Capital, concerning the potential for CWR conservation within the Natura 2000 network. Topics for discussion included the detailed mapping of potential Natura 2000 sites rich in CWR diversity and the correlation between Habitats Directive listed habitats and species, and CWR, on which further analysis will be produced as part of the Farmer's Pride project. This was a key opportunity to develop our engagement with DG Environment and this will be followed up with further advocacy in the next period. In Spain, URJC participated in a joint meeting with the Spanish Ministry for Ecological Transition and the Spanish Ministry of Agriculture. This was an opportunity to inform them about the activities on conservation of CWR in the context of the Farmer's Pride project and to present them the initiative to establish a European network of CWR genetic reserves.

A key milestone that has been developed is a concept note for the establishment of the network to explain the rationale for the establishment of the network, the aim and objectives of the network, who would be involved, what the benefits of membership would be, and how it would operate. This concept note will be used in the final year of the project by consortium partners to engage with different stakeholders, including policy makers, to endorse and support the European Network for *In Situ* Conservation and Sustainable Use of Plant Genetic Resources'.

Conclusion

In the final year of the project, Farmer's Pride will be stepping up actions to engage with the stakeholders to join the network and also to policy makers to help support and endorse the network. In this respect meetings with several key policy makers are being planned to explain the network and seek what measures they can take for the sustainable functioning of the network. These meetings will then culminate in a final Policy Round table session at the project's Final Dissemination Conference, which will be held in Troia, Portugal, at which the European network for *In Situ* Conservation and Sustainable Use of Plant Genetic Resources will be launched.

References:

ECPGR (2017). ECPGR Concept for on-farm conservation and management of plant genetic resources for food and agriculture.

FAO (2017). Sixteenth Regular Session of the Commission on Genetic Resources for Food and Agriculture. CGRFA/16/17/Report/Rev.1

ITPGRFA (2017). Seventh session of the Governing Body of the International Plant Genetic Resources for Food and Agriculture. IT/GB-7/17/Report

Létard, V., Flandre, H. and Lepeltier, S. (2004) Information Report No 195 (2003–2004) Done on Behalf of the Joint Mission of Information (1) 'France et les Français Face à la Canicule: Les Leçons d'une

Crise' (France and the French Facing a Heat Wave: The Lessons of a Crisis), 391 pp. www.senat.fr/rap/r03-195/r03-195.html.

Maxted N, Avagyan A, Frese L, Iriondo JM, Magos Brehm J, Singer A, Kell SP. (2015). ECPGR Concept for *in situ* conservation of crop wild relatives in Europe. Wild Species Conservation in Genetic Reserves Working Group, European Cooperative Programme for Plant Genetic Resources, Rome, Italy.

20 Létard, V., Flandre, H. and Lepeltier, S. (2004) Information Report No 195 (2003–2004) Done on Behalf of the Joint Mission of Information (1) 'France et les Français Face à la Canicule: Les Leçons d'une Crise' (France and the French Facing a Heat Wave: The Lessons of a Crisis), 391 pp. www.senat.fr/rap/r03-195/r03-195.html

21 Directive 2008/62/EC and Directive 2009/145/EC
22 EU Regulation 2018/848 will enter into force on 1 January 2021
23 European Cooperative Programme for Plant Genetic Resources
24 FAO (2017). Sixteenth Regular Session of the Commission on Genetic Resources for Food and Agriculture. CGRFA/16/17/Report/Rev.1
25 ITPGRFA (2017). Seventh session of the Governing Body of the International Plant Genetic Resources for Food and Agriculture. IT/GB-7/17/Report
26 Notification SCBD/SAM/DC/DCo/84808 dated 3 August 2015
27 Commission Directive 2008/62/EC, 2009/152/EC, 2010/60/EU, 2018/848 and Commission Implementing decisions C (2014) 1681
28 ECPGR(2017); Maxted et al (2015)
29 For example Sweden, Finland, Romania, Spain, United Kingdom, Austria, Italy, Germany, France, Estonia, Portugal, Latvia and Slovenia. (source: ECPGR, 2017)

Spreading the word and getting people involved

Jenny Hawley
Plantlife International, 36 Brewery Street, Salisbury SP1 2AP, United Kingdom, jenny.hawley@plantlife.org.uk

The goal of Farmer's Pride – to build a new European network for *in situ* conservation – is essentially about bringing people, organizations and existing networks together. Communications and dissemination activities are at the heart of all our work, and these are coordinated through Work Package 5.

The aims of our communications and dissemination activities are to:

1. Raise awareness of the importance of *in situ* conservation of plant genetic resources (PGR) with key stakeholders;
2. Disseminate the project outputs and outcomes effectively to stakeholders;
3. Build a strong coalition of support to better facilitate the *in situ* conservation, management and use of crop wild relatives (CWR) and landraces (LR) in Europe.

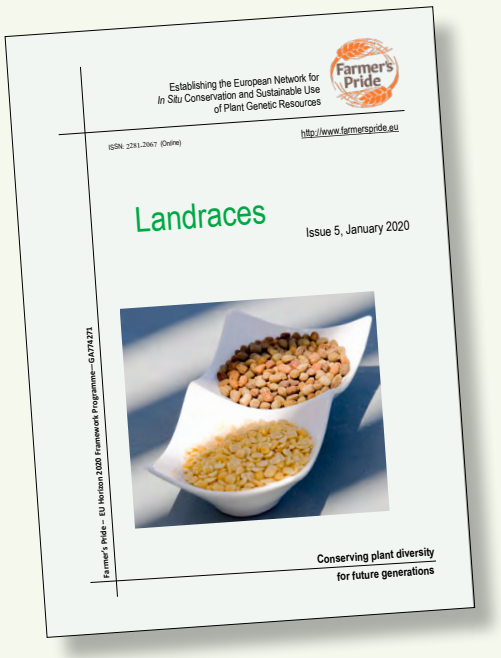
Project outputs

Work packages 1–4 are producing a range of reports, briefs and other outputs aimed at different stakeholders and these are the foundation of our communications activities. Design, publication and dissemination of these project outputs are coordinated to make sure they are consistent, engaging and timely.

Stakeholders

We have identified the following broad stakeholder groups as the priority targets for our communications and dissemination:

- Farmers and gardeners;
- Plant breeding and seed sectors;
- Plant genetic resources (PGR) conservation sector;
- Environment conservation sector;
- Policymakers.



A project factsheet is available in several languages, including Croatian, on our website.

New issues of the Landraces and Crop Wild Relatives newsletters will be produced during the project.

Our communications are tailored to each stakeholder group based on their needs and interests. In particular, our challenge is to engage those outside the PGR sector by making the issues relevant to them, using accessible language and appropriate formats. Priority subgroups and individuals within each of the stakeholder groups are being identified (e.g. landrace farmers within the broader farmer group) and we are building on communications work from previous projects and partners' own activities.

Farmer's Pride Ambassadors

An innovative element of the project is the recruitment of voluntary Farmer's Pride Ambassadors. This team of 18 (at the time of writing) represent a range of sectors and countries, including many of those not represented by the project partners. The Ambassadors are all experts in their field, providing external input into the project and helping to engage stakeholders through their own networks, contacts and events. They take part in project events, disseminate information and visit groups of stakeholders such as farmers or site managers.

For a full list of Ambassadors, see the 'Collaborators' page on the project website.

Existing networks

A key strategy of the project is to multiply the reach and impact of our activities by communicating through existing network structures, for example, each network's own newsletter, social media or other channels. These include the European Cooperative Programme for Plant Genetic Resources (ECPGR) and other national and regional networks that are represented in the project consortium:

- Arche Noah, Austria;
- Danish Seed Savers;
- Hungarian Research Institute of Organic Agriculture (ÖMKi)
- Pro Specie Rara, Switzerland;
- The Nordic Genetic Resource Centre;
- European Seed Association;
- Eurosite;
- European Association for Research on Plant Breeding via the Universitat Politècnica de València and UoB.

Policy and advocacy

The project's communications activities are closely linked to our advocacy activities, which aim to create an enabling policy environment within national governments, the EU and the UN FAO. These activities, including policy dialogues, published briefs and targeted advocacy plans, are coordinated between Work Packages 3 and 5.

Online communications

The project website www.farmerspride.eu was launched in May 2018 and this provides a focal point for our communications. It presents information about the project context, actions, publications and collaborators, with further content being added as the project progresses.

Farmer's Pride is also active on Twitter through @PGRInSitu and using #eufarmerspride. Our reach is magnified through 'reTweets' by project partners and other followers, and the account will be available for continued use after the project ends in 2020.

Follow Farmer's Pride on Twitter @PGRInSitu

Europe-wide events

In addition to national and local-level project events, annual Europe-wide events are being held to bring together the project collaborators and to drive forward progress:

- Workshop 1 held in Denmark in October 2018 – participants included representatives of the Nordic Crop Wild Relatives project and other external experts (full report is available on request);
- Workshop 2 held in Greece in October 2019;
- Workshop 3, policy dialogue workshop and final dissemination conference to be held in Portugal in September/October 2020.
-

Our 2018 stakeholder workshop in Denmark brought together the main project collaborators and external experts.

Integrated *in situ* and ex situ conservation of Crop Wild Relatives in Spain

Álvarez-Muñiz, Clara[1]; Rubio Teso, María Luisa[1]; Torres, Elena[2]; Molina, Ada[2]; Iriondo, José M.[1]

[1]Departamento de Biología y Geología, Física y Química Inorgánica, Área de Biodiversidad y Conservación, Universidad Rey Juan Carlos, Móstoles, Spain.

[2]Departamento de Biotecnología –Biología Vegetal, Universidad Politécnica de Madrid, Madrid, Spain.

Introduction

Crop Wild Relatives (CWR) are a large group of plants closely related to crops, which are a valuable source of plant diversity as a reservoir of genetic variation (Heywood *et al.*, 2007). They can be the key to successful agricultural adaptation to global change, due to their potential to supply trait variability that can contribute to crop improvement (Maxted and Kell, 2009). The conservation of CWR is becoming more and more urgent, because as wild plants, they are susceptible to the same threats that other wild species experience, such as loss, degradation and fragmentation of habitats, among others (Ford-Lloyd *et al.*, 2011). Coordination between *in situ* and *ex situ* conservation is essential to preserve them properly. Both approaches need to promote activities that create synergies and reduce vulnerabilities, including the *in situ* management and monitoring of CWR populations in genetic reserves and the establishment of back-up collections in associated gene banks, as it is done with other groups of wild flora (Laguna *et al.*, 2013). Spain, as one of the countries hosting the greatest CWR diversity in Europe —over 6,500 species (Kell *et al.*, 2008) — constitutes a very interesting place to analyse the conservation status of this type of plant genetic resources (Vincent *et al.*, 2019). Besides, CWR have been subject to previous studies in this country, that resulted in the Prioritised Spanish Checklist of crop wild relatives, containing 578 species (Rubio Teso *et al.*, 2018a).

Coordination between *in situ* and *ex situ* conservation is implemented for some groups of wild flora in Spain, however these coordination efforts do not exist when it comes to CWR. Indeed, evidence of active *in situ* CWR conservation is only found for those CWR that are endangered, endemic or rare (Laguna *et al.*, 2016; Rubio Teso *et al.*, 2018a). In any case, there are very few examples and little practical experience. Regarding the *ex situ* conservation of CWR in Spain, the pioneer germplasm bank of the Technical University of Madrid (UPM), founded in 1966 by César Gómez Campo, holds an important collection of CWR (www.bancodegermoplasma.upm.es/index.html). Other genebanks associated to botanic gardens and the National Plant Genetic Resources Centre (CRF) together hold accessions representing up to 70% of the CWR listed in the Prioritised Spanish Checklist. However, this representation does not guarantee a proper conservation of the genetic diversity of these species (Rubio Teso *et al.*, 2018b). In addition, there is the need to introduce CWR specific protocols and scoring systems to improve the procedures associated with these *ex situ* conservation actions (Díez *et al.*, 2018).

Some aspects that could explain the current scarce coordination between *in situ* and *ex situ* CWR conservation activities in Spain may include: (1) lack of awareness of the importance of conserving CWR among *in situ* conservation stakeholders; (2) limited human and financial resources; (3) methodology gaps to implement *ex situ* back-up collections of *in situ* preserved material , as well as, the challenge of defining the minimum unit of conservation; (4) ambiguous delimitation of CWR conservation responsibilities and competences, depending from agriculture administration, but needing a strong input from environment administrations; (5) administrative and legal difficulties to collect and transfer plant genetic resources among different organizations.

We have analyzed the current situation of the collaboration between *in situ* and *ex situ* CWR conservation stakeholders in Spain. The objectives of this study were: 1) to evaluate the willingness and resource availability of the main stakeholders, as well as to determine constraining factors and opportunities, 2) to collect key related experiences that could serve as model examples of collaboration, 3) to promote new alliances that give rise to pilot case studies that involve the collaboration of both *in situ* and *ex situ* conservation actors.

This study was developed in the framework of the Farmer's Pride project, funded by the Horizon 2020 programme of the European Commission (grant agreement num. 774271), whose main objective is the *in situ* conservation of wild and cultivated plant diversity to safeguard food, nutritional and economic security.

Methodology

To address whether some collaboration between *in situ* and *ex situ* CWR conservation actions was already taking place in Spain, potentially interested stakeholders were individually contacted and asked about their roles in CWR conservation and their collaboration with other institutions. After that, all respondents were called to a joint meeting. Stakeholders were protected area managers, germplasm bank curators (mainly linked to the conservation of wild plant species) and public administrations.

The meeting was conducted via Skype and our research group at the Rey Juan Carlos University participated as moderator.

Participants were asked to provide their vision on the interests, needs and prospects regarding the conservation of CWR. Possible limitations to work in a coordinated manner and previous similar experiences to learn from were also asked. At the end of the meeting potential actions and ideas to enhance joint conservation initiatives were actively discussed. Finally, out of all participants contacted, two institutions were identified and proposed to participate in a pilot experience that will coordinate *in situ* and *ex situ* CWR conservation activities. The experience gathered from this pilot study will enable, in due time, the publication of a set of guidelines for exemplar *in situ* and *ex situ* CWR conservation.

Results and discussion

In situ conservation of CWR: first assessments

Most managers of protected areas and staff from public administrations were unaware of their own role in the conservation of CWR. According to them, the subject seemed interesting but pointed out that they were not engaged in any actions to conserve CWR. After providing a detailed definition of crop wild relatives and indicating that some of them were endangered taxa, they realised that some CWR species are already included in their conservation programmes. Therefore, becoming aware of the important role that they can actually play in the *in situ* conservation of CWR. The large area covered by protected areas ensures the passive conservation of many species of CWR known to occur in these places. Moreover, different actions of active conservation (including at least censuses and monitoring of species) are performed for CWR that are threatened, rare or endemic, and included in the protected areas management plans.

Ex situ conservation of CWR: first assessments

In this case, some previous work related to CWR conservation had already been developed by Spanish genebanks. Similarly, most of them have accessions of CWR species, although they are mostly endangered, rare or endemic. An exception to this is the National Plant Genetic Resources Centre, which holds a CWR collection that has recently being extended thanks to a collaboration with The Crop Trust Project.

Joint meeting: main patterns

To further discuss this collaborative effort, on March 22nd 2019, seven members from institutions representing genebanks, protected areas, and public administrations joined an online meeting. There was a common interest between participants in cooperating together. It was widely recognised that endangered, rare or endemic CWR could be a good starting point that will facilitate collaboration among institutions. In this light, activities that are already being executed could be given an added value without the need for extra funds. Possibilities for preserving non-threatened CWR species, non-protected by legislation, were reported to be very limited, since CWR in Spain do not have specific plans for their conservation and the activities of all stakeholders are greatly dependent on existing legal mandates. It was noted that some other major constraints in the two types of conservation are the lack of both economic and personnel resources, as well as bureaucratic, administrative and legal difficulties to the exchange of material and the creation of agreements. The complexity of the legislative and administrative processes was reported by all participants. Although there are some peculiarities, all of them noted that **(1)** the regulation to access or transfer CWR material is very complex, dependent on the final use of the species and the use of the related crop of the CWR – differing from relatives of food and forage crops and the other CWR–; **(2)** the collection of CWR taxa that are not protected by law as threatened species depends on the Autonomous Communities (subnational administrative instances in Spain), and **(3)** if the protected area has a regulation to collect seeds from species occurring within its limits, it will also be necessary to request such permission. Other aspects to take into account are the phytosanitary requirements of the exchanged material, which are set out according to its final destination. Finally, how CWR are managed at the national and subnational scales depends largely on whether they have legal protection as threatened species. Those included in national or regional catalogues of protected species in Spain (Rubio Teso et al., 2018b) are managed by the Ministry of Environment or Departments of Environment of the Autonomous Communities, whereas the Ministry of Agriculture is responsible for those CWR that are not legally protected, a fact that makes joint actions for CWR conservation difficult.

Previous key experiences

Previous experiences of coordinated conservation activities between protected areas and genebanks were common for all participants. This experience could be the basis for the same type of cooperation for CWR conservation. All the participants agreed on the mutual benefit that one type of conservation implies for the other, and several cases of successful collaborative experiences were identified. All of them reported experiences that linked *in situ* and *ex situ* conservation, mainly through the exchange and transference of material in both directions, either to deposit in genebanks seeds collected in protected areas or to facilitate material preserved in genebanks to reintroduce or reinforce populations of certain species.

Next steps

New possibilities of *in situ* – *ex situ* coordination for CWR conservation arose from the meeting held. Rey Juan Carlos University offered all interested participants the possibility to provide them with a list of Spanish prioritised CWR that occur within their territories if an inventory of their flora species is facilitated, as well as general support for future coordination.

Testing a back-up strategy through a pilot experience

Both the genebank "César Gómez-Campo" at the Technical University of Madrid and the Biosphere Reserve "Sierra del Rincón" were identified as potential stakeholders to test a back-up strategy. During 2019, 15 CWR species from the Spanish Prioritised Checklist occurring in the reserve were selected and

their populations characterised (georeferenced and censused) *in situ*. Then, seeds were collected and *ex situ* conserved at the genebank, thus starting a collection of CWR of this reserve. The pilot experience will be evaluated once the whole collection is completed, however activities are likely to continue further so the collection could expand in coming years. This experience will be used to design a set of guidelines to enhance the integration of *in situ* and *ex situ* CWR conservation activities. These guidelines will be published for its distribution among all potential national and international interested stakeholders and agents of *in situ* and *ex situ* conservation.

References

Díez, M. J. *et al.* (2018) 'Plant genebanks: Present situation and proposals for their improvement. The case of the Spanish Network', *Frontiers in Plant Science*, 9, pp. 1–13. doi: 10.3389/fpls.2018.01794.

Ford-Lloyd, B. V. *et al.* (2011) 'Crop wild relatives—Undervalued, underutilized and under threat?', *BioScience*, 61(7), pp. 559–565. doi: 10.1525/bio.2011.61.7.10.

Heywood, V. *et al.* (2007) 'Conservation and sustainable use of crop wild relatives', *Agriculture, Ecosystems and Environment*, 121(3), pp. 245–255. doi: 10.1016/j.agee.2006.12.014.

Kell, S. P. *et al.* (2008) 'Crops and wild relatives of the Euro-Mediterranean region: Making and using a conservation catalogue.', in Maxted, N. et al. (eds) *Crop wild relative conservation and use*. Wallingford, UK: CABI Publishing, pp. 69–109.

Laguna, E. *et al.* (2013) 'Relevant plant recovery programmes. Conservation management of plant micro-reserves and ecological restoration', in Kadis, C., Thanos, C. A., and Laguna, E. (eds) *Plant micro-reserves: from theory to practice. Experiences gained from EU LIFE and other related projects.* Athens: Utopia, pp. 127–140.

Laguna, E. *et al.* (2016) 'Role of micro-reserves in conservation of endemic, rare and endangered plants of the Valencian region (Eastern Spain)', *Israel Journal of Plant Sciences*. Taylor & Francis, 63(4), pp. 320–332. doi: 10.1080/07929978.2016.1256131.

Maxted, N. and Kell, S. P. (2009) 'Establishment of a global network for the *in situ* conservation of crop wild relatives: status and needs', *FAO Commission on Genetic Resources for Food and Agriculture*, pp. 1–266.

Rubio Teso, M. L., Torres, E., *et al.* (2018a) 'National inventory and prioritization of crop wild relatives in Spain', *Genetic Resources and Crop Evolution*, 65(4), pp. 1237–1253. doi: 10.1007/s10722-018-0610-0.

Rubio Teso, M. L., Parra-Quijano, M., *et al.* (2018b) 'Identification and assessment of the crop wild relatives of Spain that require most urgent conservation actions', *Mediterranean Botany*, 39(2), pp. 67–75. doi: 10.5209/mbot.60074.

Vincent, H. *et al.* (2019) 'Modeling of crop wild relative species identifies areas globally for *in situ* conservation', *Communications Biology*, 2(1), pp. 1–8. doi: 10.1038/s42003-019-0372-z.

Farmer's Pride 'Networking Options': aims and initial results

Valeria Negri and Lorenzo Raggi

Università degli Studi di Perugia, Borgo Giugno 74, 06121 Perugia (I), valeria.negri@unipg.it

The 'Networking Options' workpackage is aimed at

i) understanding 'who' are the stakeholders and what are their main interests concerning *in situ* maintained resources

ii) reviewing the options available for a future network of stakeholders and sites

iii) providing 'showcases' and exemplary collaboration platforms as potential models for European-wide/broader European implementation of a network (specifically how CWR and LR populations at multiple sites are managed by multiple stakeholders and can be integrated to mutual PGRFA conservation and use benefit)

iv) deepening the knowledge on current in situ LR and CWR diversity conservation activities and sites (e.g. location, type, related crop, richness by site)

v) identifying hotspots of LR *in situ* diversity and vi) developing a LR and CWR network model for both European an National implementation. All Partners and Famer's Pride Ambassadors are involved in WP1 whose overall outputs will also serve to develop the other workpackages.

In order to understand: 'who' are the stakeholders by categories of interest for PGRFA conservation (from public bodies to private citizens) and their willingness to join the future network, a survey was launched online through the project website on May 5th 2018. The survey was widely diffused across countries. At the closure of the survey (on April 1st 2019) a total of 1,022 single replies were collected from 35 different European Countries. Turkey, Italy and Spain, followed by Hungary, Greece and Finland, were clearly the countries most interested in the initiative. Indeed, we recorded a relevant interest, in Europe; especially vivid is this interest by farmers and farmer organizations for (*sensu lato*) LR and by protected site managers for CWR and habitat/wild plant species (Figure 1).

In main Europe more than 40% of respondents are already part of a conservation network and there is a high interest in being part of a European *in situ* network: more than 70% of the respondent are interested. The situation is quite different in Turkey where less than 20% of respondents are already part of a network and less than 50% is interested in joining the future *in situ* conservation network (Figure 2). In both main Europe and

Turkey, the key interest of respondents is in “conservation of genetic diversity per se” and in “research” on genetic resources; the “direct utilisation” of PGRFA is also relevant in main Europe.

Further information on the survey results can be found at https://more.bham.ac.uk/farmerspride/wp-content/uploads/sites/19/2019/10/D1.1_Identify_in_situ_stakeholders.pdf.

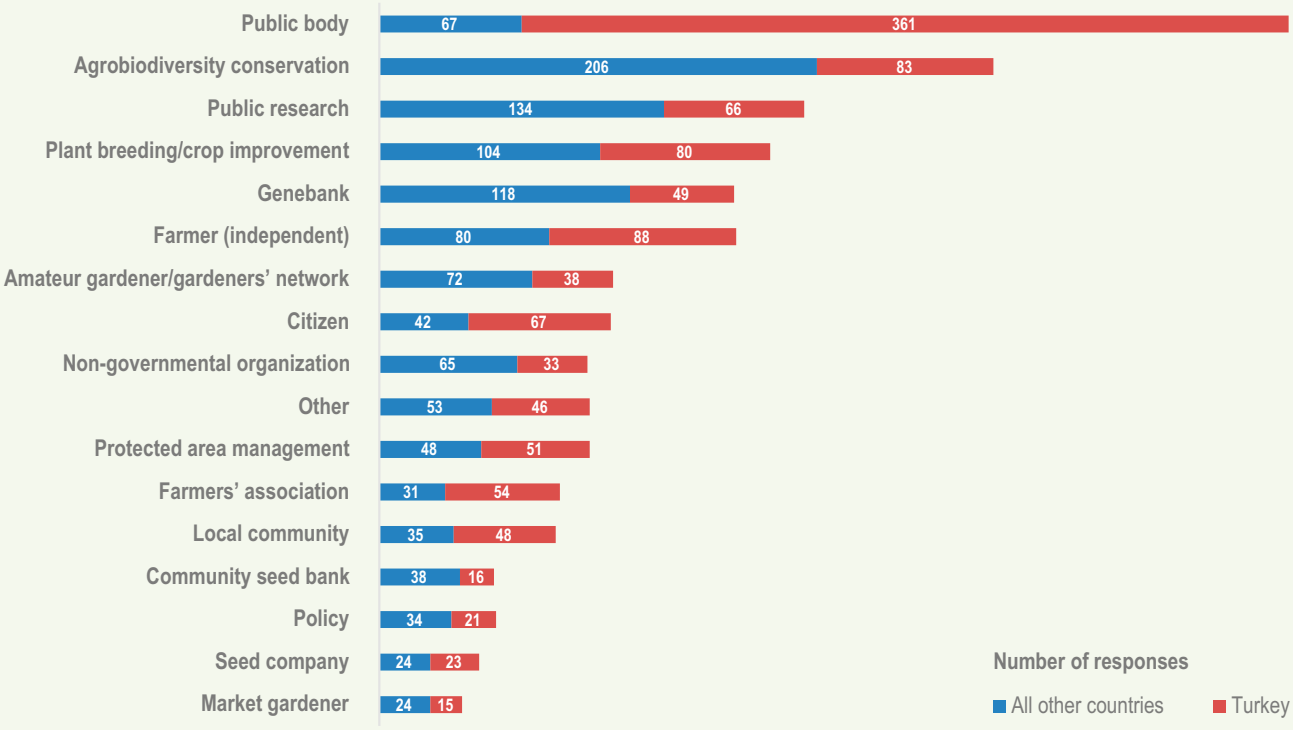


Figure 1. Types of organizations respondents associated with and/or their individual areas of work/interests (if not associated with an organization). The total numbers of options selected were 1,139 from 555 respondents (Turkey) and 1,175 from 467 respondents (all other countries). Due to the disproportionate number of responses received from Turkey, results for Turkey are presented separately.

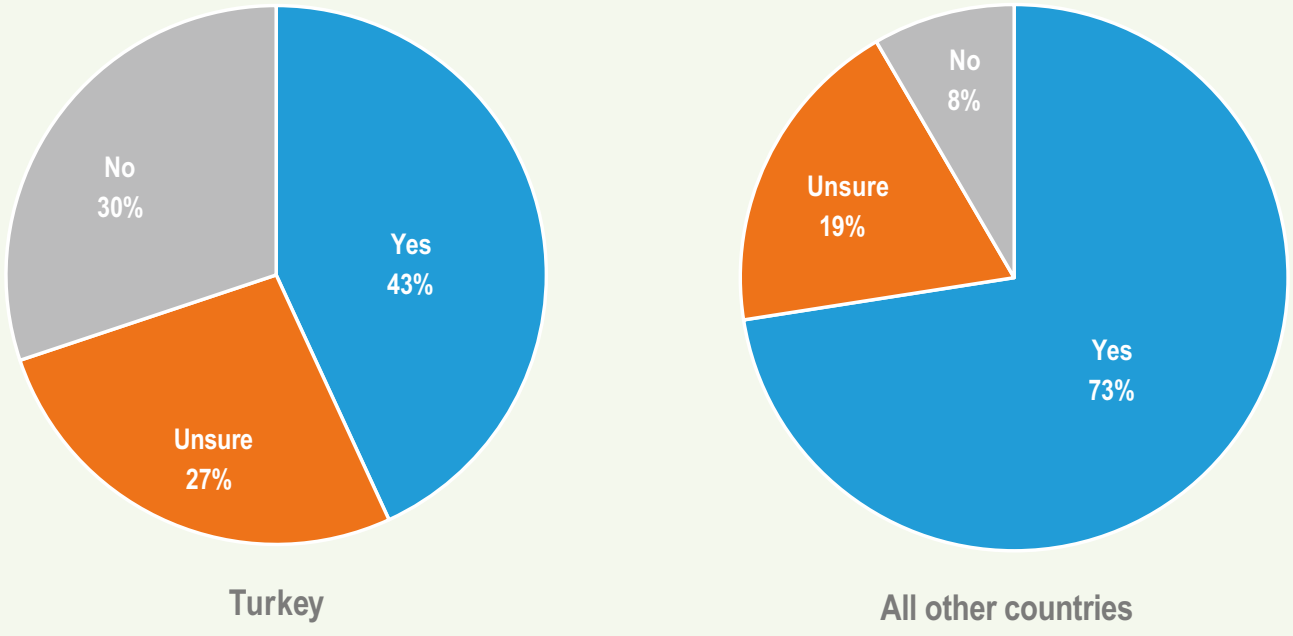


Figure 2. Interest in joining the future European Network (Turkey: n = 555; All other countries: n = 467).

Another look at *in situ*/ex situ CWR conservation linkage

N. Maxted

School of Biosciences, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK. Email: n.maxted@bham.ac.uk

One key aim of CWR conservation is to maximise the available genetic diversity for the user community to use in sustaining crop improvement. This can most effectively be achieved by a combination of complementary *in situ* and *ex situ* activities (Maxted *et al.*, 1997). In such an approach, the two conservation strategies complement each other and provide a safety back-up for each other, although it is understood that the range of *in situ* and *ex situ* techniques applied each have their specific advantages and disadvantages (Maxted *et al.*, 2020). The need to maximise the diversity available has been exacerbated by the growing impact of the human population and climate crises. CWR users have sought greater breadth of genetic diversity to sustain cultivar production (McCouch *et al.*, 2013; IPCC, 2014). A breadth of diversity not currently met by *ex situ* germplasm holdings alone. Castañeda-Álvarez *et al.* (2016) found 71.1% of taxa were ranked as high priority for further collecting and only 4.2% were already adequately conserved. Further, although the Global Crop Diversity Trust initiative "Adapting Agriculture to Climate Change: Collecting, Protecting, and Preparing Crop Wild Relatives" (www.cwrdiversity.org/; Dempewolf *et al.*, 2013) stimulated CWR collection and several thousand additional seed collections have been made for *ex situ* storage, it remains to be assessed how impactful this initiative has been and whether it in turn stimulates further *ex situ* collection post-project.

Historically, CWR diversity active conservation has focused almost exclusively on *ex situ* activities and there has been no systematic approach to active CWR *in situ* conservation (Maxted *et al.*, 2016). Therefore, given the unsystematic *ex situ* coverage, it is not surprising genetic resource centres alone have been unable to supply the breadth of CWR diversity the user community requires. Maxted *et al.* (2020) concluded that both the *ex situ* and particularly the *in situ* genetic conservation communities needed to 'up their games' to meet users demands. In the context of *in situ* CWR genetic conservation, networks of sites/populations for active genetic reserves (or on-farm activities) is the desirable route because it would (Maxted *et al.*, 2014):

- Facilitate coordination to maximise best practice.
- Foster stronger partnerships between PGR stakeholders at national, regional and global levels.
- Foster stronger partnerships between PGR and broader biodiversity stakeholders.
- Enable closer links between local communities managing PGR diversity and the formal PGR sector.
- Enable active *in situ* conservation and dynamic safeguarding in perpetuity of important PGR.
- Improve linkages between formal PGR conservation and local sustainable use.
- Significantly enhance PGR diversity available to users, particularly in crop improvement.

It is worth underlining that a network of sites/populations for active CWR *in situ* conservation would be likely to, in time, at least 'double' the diversity available to users. However, being able to double the diversity available to users, assumes that CWR genetic diversity conserved *in situ* is equally available as *ex situ* conserved diversity has been to the user community.

It seems fundamental that if *in situ* and *ex situ* approaches are to be truly complementary, then germplasm must be as easily available to the user community from both *in situ* as well as *ex situ* conserved resources. This requirement stimulated recent debate concerning use of CWR held *in situ* in genetic reserves (Valdani Vicari & Associati *et al.*, 2015, 2016; Maxted *et al.*, 2015, 2017). The brutal conclusion was that currently there is no *in situ* to utilisation link and without such a link, there would necessarily be a lower priority for CWR *in situ* conservation. Improving the *in situ* conserved resource utilisation link is essential to systematic and sustainable *in situ* conservation implementation. Further, concern has been raised over the potential additional and significant financial burden that would be placed on genetic resource centres if they were required to incorporate *in situ* back-up samples into their *ex situ* collection and make them available to users (Valdani Vicari & Associati *et al.*, 2016). A possible fundamental restriction limiting *in situ* PGR conservation.

Maxted and Palmé (2016) suggested a potential model for how *in situ* and *ex situ* CWR conservation might be effectively linked (Figure 1). It involved a distinction between standard *ex situ* sampling of CWR population for conservation and user distribution and populations sampled for *in situ* back-up. Populations sampled for *in situ* back-up would be similar to 'black box' samples, relatively small seed population samples held for safety, but only available to the donor as part of their *in situ* monitoring programme or population reinforcement, but not routinely monitored, regenerated or made available to the user community. The most expensive element of *ex situ* storage is regular population regeneration to maintain germination levels and this would not occur for *in situ* back-up samples. Such an approach would significantly reduce the potential cost of *in situ* back-up and the need to maintain germination levels would be met by regular re-sampling and *in situ* back-up sampling. However, Maxted and Palmé (2016) did recommend that where genetic resource centre resources were more generous the genetic resource centre manager may prefer not to distinguish between standard *ex situ* and *in situ* back-up CWR samples, making both sets of accessions available to users, providing the *in situ* site manager agreed.

However, the distinction between standard *ex situ* and *in situ* back-up accessions means the user would need to access the *in situ* population sample/accession from the *in situ* site

manager and not the genetic resource centre from whom they have previously obtained accessions. It was proposed that the *in situ* or on-farm resource would be made available by the *in situ* resource maintainers (protected area managers or farmers). Thinking about this further it is practically unrealistic. Both protected area managers or farmers are unlikely to have any experience of receiving requests for germplasm, processing such a request and supplying germplasm with the appropriate SMTA to the end user in a timely manner. As their core activities have previously not included germplasm supply, practical experience has shown they are reluctant to take on such an additional role, though this could perhaps be overcome by appropriate training and incentives.

Further seasonality and regularity of supply would also be a limitation on supply efficiency. Accessions in genetic resource centres are available for distribution year round, but germplasm is normally supplied in the form of seed samples and seed samples are usually only available *in situ* or on-farm for few weeks of the year following fruit ripening. Genetic resource centres, because they have large collections of accessions, have a steady supply of requests for material, whereas an *in situ* or on-farm site with more limited numbers of user available samples may go several years between requests. In contrast, the prime function of genetic resource centres is germplasm supply and they have routine procedures in place to maximise efficiency. As such germplasm supply from *in situ* or on-farm sites direct would be impractical.

Therefore, a third practical option is suggested in Figure 2 to add to the two existing options, *in situ* back-up germplasm samples would be transferred to the genetic resource centre periodically (≈ once every 10 years) and pass through the normal registration and documentation, cleaning and drying, germination testing and then packed and banked process, but the sample would not be regenerated (so reducing maintenance costs), but would be made available. The initial seed sample supplied to the genetic resource centre would need to be larger to allow for sample distribution and further samples could be supplied by the *in situ* maintainer from the regular *in situ* back-up or on request as stocks are depleted through meeting user's demand. The *in situ* back-up sample like any other germplasm sample would be recorded in the genetic resource centres documentation system and flagged as available to the user community. In this way the function of the genetic resource centre would be enhanced to cover access to both germplasm conserved *ex situ* and *in situ,* expanding their role from gene banks to genetic resource centres (Maxted *et al.*, 2016). The regular re-sampling of the *in situ* population for *in situ* back-up would obviate the need for germination monitoring or regeneration and the lack of the latter would significantly reduce

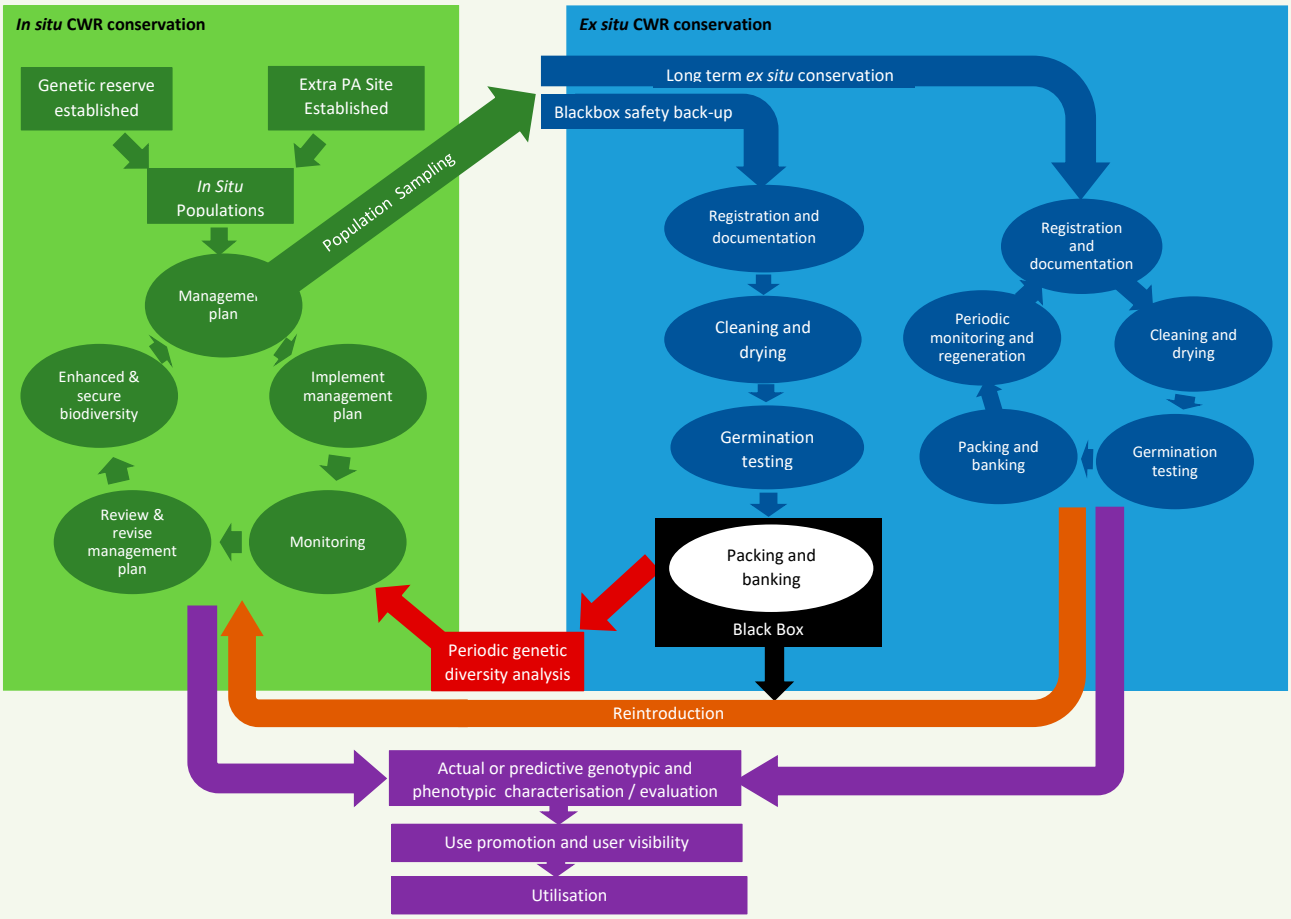


Figure 1. Integrating *in situ* and *ex situ* CWR conservation with use (Maxted and Palmé, 2016).

the financial burden of *in situ* germplasm supply on the plant genetic resource centre and it would facilitate access to the *in situ* conserved resource and avoid direct contact with the *in situ* site manager or farmers. Though it should be noted that *in situ* site manager or farmers interest would be preserved by the ABS agreement signed between the resource manager and the plant genetic resource centre.

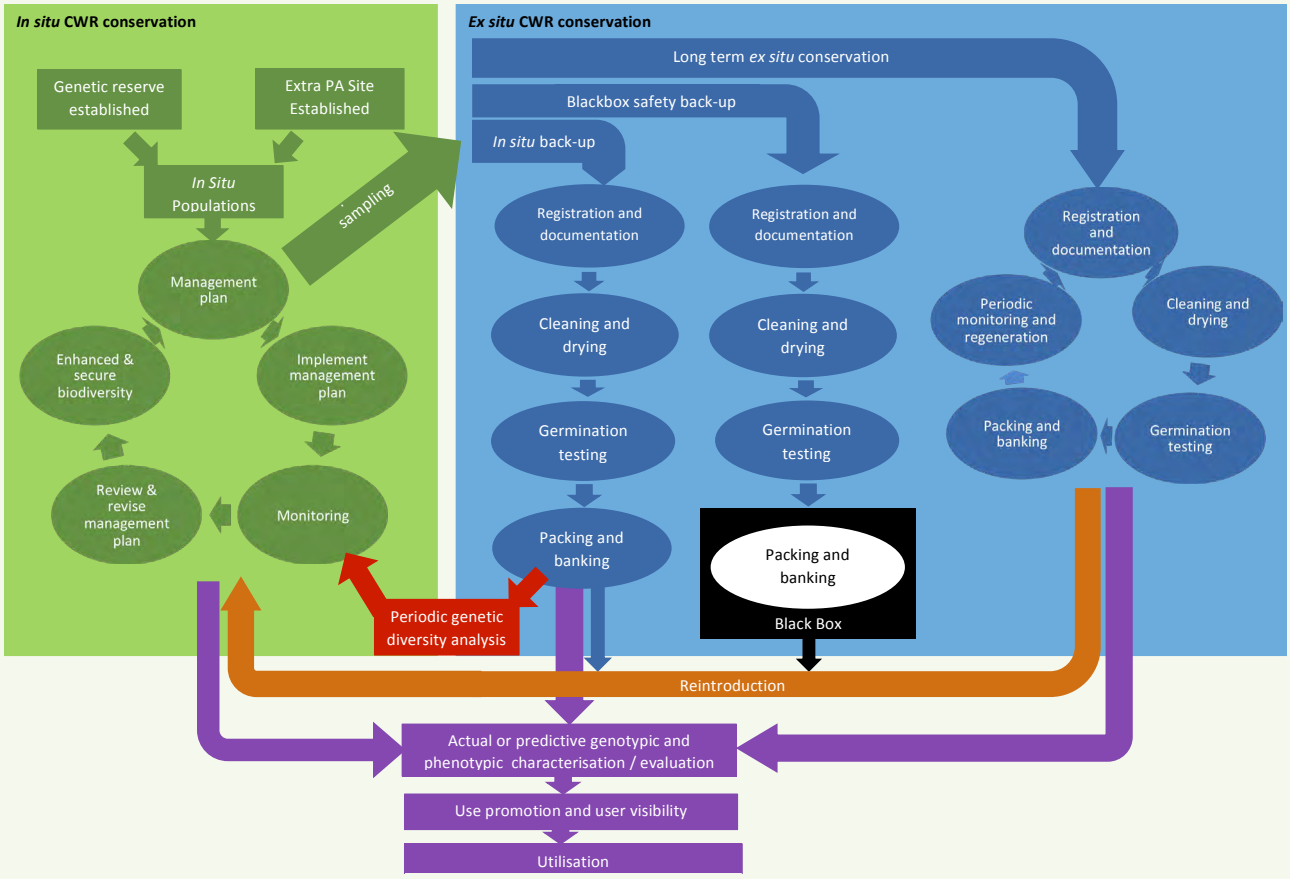


Figure 2. Integration of *in situ* and *ex situ* CWR conservation with utilisation. Note PA=protected area.

References

Castañeda-Álvarez, N.P., Khoury, C.K., Achicanoy, H.A., Bernau, V., Dempewolf, H., Eastwood, R.J., Guarino, L., Harker, R.H., Jarvis, A., Maxted, N., Müller, J.V., Ramírez-Villegas, J.A., Sosa, C.C., Struik, P.C., Vincent, H. and Toll, J., (2016a). Global priorities for crop wild relative conservation for food security. *Nature Plants,* 16022.

Dempewolf, H. Eastwood, R.J.; Guarino, L., Khoury, C.K., Müller, J.V. and Toll, J. (2013) Adapting Agriculture to Climate Change: A Global Initiative to Collect, Conserve, and Use Crop Wild Relatives. *Agroecology and Sustainable Food Systems*, 38, 369–377.

IPCC, (2014). *Climate Change 2014: Synthesis report: Longer report*. Available at: www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_LONGERREPORT.pdf (Accessed 03 November 2014).

Maxted N., Amri. A., Castañeda-Álvarez, N.P., Dias, S., Dulloo, M.E., Fielder, H., Ford-Lloyd, B.V., Iriondo, J.M., Magos Brehm, J., Nilsen, L-B., Thormann, I., Vincent, H. and Kell, S.P., (2016). Joining up the dots: a systematic perspective of crop wild relative conservation and use. In: Maxted, N., Ehsan Dulloo, M. & Ford-Lloyd, B.V. (eds.), *Enhancing Crop Genepool Use: Capturing Wild Relative and Landrace Diversity for Crop Improvement*. Pp. 87-124. CAB International, Wallingford, UK.

Maxted, N. and Palmé, A., (2016). *Combining ex situ and in situ conservation strategies for CWR to mitigate climate change*. In: *The impact of climate change on the conservation and utilization of crop wild relatives in Europe* (Eds. Valdani Vicari & Associati *et al.*), Barcelona, Spain, 15th December 2015. Preparatory action on EU plant and animal genetic resources (AGRI-2013-EVAL-7) Workshop Report, Directorate General for Agriculture and Rural Development, European Commission, Brussels, Belgium.

Maxted, N., Avagyan, A. Frese, L., Iriondo, J.M., Magos Brehm, J., Singer, A. and Kell, S.P., (2015). *Preserving diversity: a concept for* in situ *conservation of crop wild relatives in Europe Version 2.* Rome, Italy: *In Situ* and On-farm Conservation Network, European Cooperative Programme for Plant Genetic Resources, Rome, Italy. Available online: www.pgrsecure.org/documents/Concept_v2.pdf (accessed 11.05.17).

Maxted, N., Ford-Lloyd, B.V. and Hawkes, J.G., (1997). Complementary Conservation Strategies. In: *Plant genetic conservation: the* in situ *approach* (eds. Maxted, N., Ford-Lloyd, B.V. and Hawkes, J.G.), pp. 20-55. Chapman & Hall, London, UK.

Maxted, N., Hunter, D. and Ortiz Rios, R.O., (2020). *Plant genetic conservation*. 560 pp. Cambridge University Press, Cambridge.

Maxted, N., Kell, S. and Magos Brehm, J., (2014). *Global Networking on in situ Conservation and on-farm Management of Plant Genetic Resources for Food and Agriculture*. Food and Agriculture Organization of the United Nations, Rome, Italy. 14 pp. www.fao.org/3/a-mm537e.pdf

Maxted, N., Labokas, J. and Palmé, A., (2017). *Crop wild relative conservation strategies. Planning and implementing national and regional conservation strategies*. Proceedings of a Joint Nordic/ECPGR Workshop, 19-22 September 2016, Vilnius, Lithuania. European Cooperative Programme for Plant Genetic Resources, Rome, Italy.

McCouch, S., Baute, G.J., Bradeen, J., Bramel, P., Bretting, P.K., Buckler, E., Burke, J.M., Charest, D., Cloutier, S., Cole, G., Dempewolf, H., Dingkuhn, M., Feuillet, C., Gepts, P., Grattapaglia, D., Guarino, L., Jackson, S., Knapp, S., Langridge, P., Lawton-Rauh, A., Lijua, Q., Lusty, C., Michael, T., Myles, S., Naito, K., Nelson, R.L., Pontarollo, R., Richards, C.M., Rieseberg, L., Ross-Ibarra, J., Rounsley, S., Sackville Hamilton, R.S., Schurr, U., Stein, N., Tomooka, N., van der Knaap, E., van Tassel, D., Toll, J., Valls, J., Varshney, R.K., Ward, J., Waugh, R., Wenzl, P. and Zamir, D., (2013) Agriculture: Feeding the future. *Nature*, 499 (7456): 23-24.

Valdani Vicari & Associati, Arcadia International, Wageningen UR: Centre for Genetic Resource, the Netherlands, Plant Research International and the socio-economics research institute, Fungal Biodiversity Centre of the Royal Academy of Arts and Science and Information and Coordination Centre for Biological Diversity of the German Federal Office for Agriculture and Food, (2015). *Better integration of ex situ and in situ approaches towards conservation and sustainable use of GR at national and EU level: from complementarity to synergy*. Workshop Report for Preparatory action on EU plant and animal genetic resources (AGRI-2013-EVAL-7). Directorate General for Agriculture and Rural Development, European Commission, Brussels, Belgium.

Valdani Vicari & Associati, Arcadia International, Wageningen UR: Centre for Genetic Resource, the Netherlands, Plant Research International and the socio-economics research institute, Fungal Biodiversity Centre of the Royal Academy of Arts and Science and Information and Coordination Centre for Biological Diversity of the German Federal Office for Agriculture and Food, (2016). *The impact of climate change on the conservation and utilisation of crop wild relatives in Europe*. Workshop Report for Preparatory action on EU plant and animal genetic resources (AGRI-2013-EVAL-7). Directorate General for Agriculture and Rural Development, European Commission, Brussels, Belgium.

CAPFITOGEN toolbox: adapting its operation according to the needs of the PGR community

Mauricio Parra-Quijano[1]

[1]CAPFITOGEN programme coordinator. Facultad de Ciencias Agrarias, Universidad Nacional de Colombia sede Bogotá, Colombia.

Background

The Plant Genetic Resources (PGR) community develops scientific studies in order to achieve efficient agricultural biodiversity conservation and utilisation. These studies not only require some techniques from different research areas, but also others specifically designed for particular needs. It implies PGR researchers have to use several methods to obtain the data and tools (usually software) to analyse them. Finding these diverse tools and learning to know how to use them represents a great challenge for most researchers, due to the great investment of time in searching for the tools, exploring their functions and performance and training in their use. The terms and duration of research projects are not usually in accordance with the time required to find and use the proper software tools for better data analysis. Therefore, scarce or null availability of specific software tools and their corresponding training is a common bottleneck for the research activities carried out by the PGR community.

In 2012, the International Treaty on Plant Genetic Resources for Food and Agriculture (www.fao.org/plant-treaty) with the funding of the Spanish government launched the CAPFITOGEN programme, which was initially focused on capacity building and knowledge transfer for National Programmes on PGR of Latin America countries. However, early in the design of this programme, the absence of specific technology for PGR analysis to be transferred was identified as an important disadvantage. Then, CAPFITOGEN turned into a technology development programme and its subsequent dissemination as a software toolbox. Since target countries are particularly rich in plant genetic resources, but have few economic and human resources, the technology was chosen according to two criteria:

1) Low equipment cost and

2) its ability to make the best use of the already available germplasm data. These criteria were achieved through the development of R scripts, which provide methodologies from published research articles about the application of geographic information system (GIS), spatial and ecogeographic analysis on species presence records and passport, characterisation and evaluation germplasm

Figure 1. The CAPFITOGEN programme website home page: http://capfitogen.net

data. Each script configured one CAPFITOGEN tool, which is delivered in a user-friendly interface that has to be downloaded and installed locally on a personal computer (PC), under a Windows OS.

Expansion phase

As the tools were developed, they were progressively disseminated through national and regional training workshops. The interest in the CAPFITOGEN tools exceeded initial expectations when support and training were requested from countries beyond Latin America. From the first workshop (Colombia, 2013) in which only two tools were delivered, to the last,15th CAPFITOGEN training event (China, 2018) where more than 350 PGR technicians from about 40 different countries were trained, offering a final set of 17 tools. According to Google Scholar, CAPFITOGEN tools have been applied in at least 23 different published studies (scientific papers and reports) during the period 2015–2019.

What the tools offer

The tools offer a wide range of data analysis that supports key activities for *in situ* or *ex situ* conservation of plant genetic resources and the promotion of their utilisation. However, some of them were designed to facilitate the use of other tools, avoid errors during the further execution of the "main" tools, or check the format or the quality of the data. Methods offered as tools take advantage of spatial and ecogeographic approaches on plant genetic resources, most of them based on the application of GIS techniques and the use of georeferenced elements, such as presence and passport data. On this methodological basis, other types of statistical analyses were added allowing addressing many technical needs that curators and PGR researchers have expressed during the workshops. Thus, new functionalities and capabilities were added to the tools, including:

- Multivariate analysis usually applied for germplasm characterisation data. A specific tool for ecogeographical germplasm characterization (Parra-Quijano *et al*., 2012a) was provided.
- Ecogeographical representativeness analysis of germplasm collections (Parra-Quijano *et al*., 2008).
- Geographic neighbourhood clustering analysis to detect diversity hotspots (similar to van Zonneveld *et al*. (2012)).
- Optimised collecting designs (García *et al*., 2017).
- Filtering and modelling methods to identify potential accessions for breeding programmes (based on Mackay's (1995) ideas) for predicting characterization (Thorman *et al*., 2014).
- Zonification techniques to determine spatio-temporal seed transfer zones (Thomas et al., 2017).
- Species distribution models to identify present or future collecting priorities, among others (Parra-Quijano *et al*., 2012b).

Troubles arise

Despite the initial objectives achieved, the wide dissemination of the tools and the recognition of their usefulness in terms of utilisation evidences and training demand, and some aspects

Figure 2. Technicians from different countries have benefited from the development of the CAPFITOGEN technology and its posterior transfer. Here some Asian forest genetic resources researchers are using CAPFITOGEN tools during a training event in 2018.

to improve remain. The current size of the installer (about 2.6 Gb) and the set of GIS layers required for several processes (compressed files ranging from 10 to 500 Mb) demand a long download time. In addition, the installer sometimes fails at the moment of installing the R software library or configuring Java in Windows OS, which leads to problems when starting the tools or when connecting R and the virtual server.

On the other hand, The CAPFITOGEN tools utilisation does not require previous R language knowledge by the users, through an HTML and PHP interface connected with a virtual server. The virtual server allows advantage to be taken of internet browsers to present simple and easy to complete forms, from where the parameters that control each function of each tool are introduced by the user. Sometimes unsuccessful installations do not allow or break the link between the interface and the virtual server. When those problems arise during training sessions, they can be solved with the trainer's intervention and, at the end, the trainees can bring their PCs back with a fully functional version of the tools. In any case, solving these problems is a time-consuming activity during training events. However, installation problems can be a real limitation when users without any previous training install and use the tools by themselves. The CAPFITOGEN programme coordination receives more than 25 emails annually with questions about how to solve the installation problems from non-trained users.

CAPFITOGEN on server – a new phase

Solutions to overcome troubles derived from the tools' installation process and the installer size have been considered since 2015 as a part of a second phase under the ITPGRFA sponsorship. Installing the tools in a "true" server and making them operate from there as an online data analysis system was proposed as the better option. Unfortunately, the Spanish funding ended in that period, and the CAPFITOGEN programme entered a stand-by mode, in which only on-demand training activities would be attended. However, the webpage (capfitogen.net), minimum maintenance of the tools and user assistance continued. The Universidad Nacional de Colombia has been in charge of the coordination of the CAPFITOGEN programme and its maintenance from 2017 to the present, since the programme coordinator, tools developer and main trainer got a position as a researcher in this institution.

In 2018, the "CAPFITOGEN on server" idea was considered again due to the interest of the Farmer's Pride project coordinators (www.farmerspride.eu/) in repowering the tools and promoting their use by the PGR community. In order to achieve these goals, an agreement between the University of Birmingham and Universidad Nacional de Colombia was reached in 2019. Important developments for the CAPFITOGEN programme were included in the contract, as follows:

- Deployment of the CAPFITOGEN tools in a server. This requires the design of an online system with user registration and the ability to simultaneously run multiple processes in R on the server. Once this system is running, users will not need to download or install anything locally. Server analysis capacity will be greater than any PC, then highly demanding processes, such as global modelling analysis, would not be a future limitation for users. Record of users, easy update and release of new functions and tools will now be possible.
- Completion of three previously developed tools. A user manual for those tools was not written when they were developed.
- A new tool will be developed under this agreement. This new tool will be specifically designed to meet the particular needs of the Farmer's Pride project and will, at the same time, be useful for the rest of the PGR community.
- Improvements in the current version. Reduction of installer and GIS layers size in Mb will reduce the time spent in its download.

Conclusions

The CAPFITOGEN tools represent a great opportunity for efficient plant genetic resources conservation and utilisation, facilitating key data analysis using low-cost inputs. Originally thought to be of use for scarce economic and human resources, but rich agricultural biodiversity environments, these tools have exceeded geographical and cultural boundaries since the needs of the PGR community are common. New perspectives arise from the recent challenges that the CAPFITOGEN programme is currently facing and from the ones that it will have to deal with in the near future. With the support of particular projects, such as Farmer's Pride, this technology will be able to reach more users globally, reducing obstacles for its use and requirements to run the analysis.

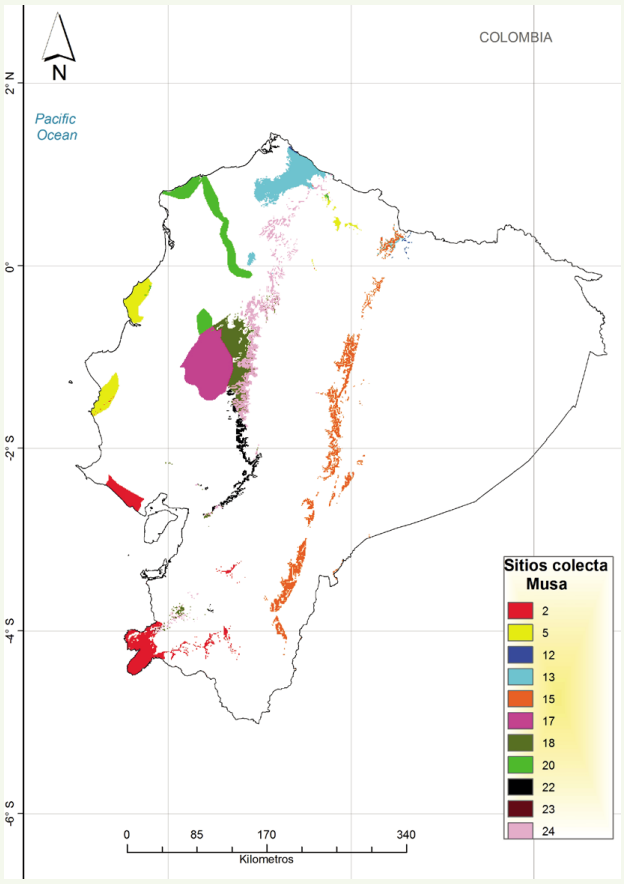


Figure 3. An example of CAPFITOGEN tools utilisation. In this case, Ecuadorian researchers determined the most prioritised sites to collect *Musa* species germplasm. Adapted from "Representatividad de la diversidad del género Musa en el Ecuador," by C. Tapia, N. Paredes and L. Lima, 2019, *Ecuador es calidad: Revista Científica Ecuatoriana*, *6*(1).

References

García, R. M., Parra-Quijano, M., & Iriondo, J. M. (2017). A multispecies collecting strategy for crop wild relatives based on complementary areas with a high density of ecogeographical gaps. *Crop Science*, *57*(3), 1059-1069.

Mackay, M. C. (1995). One core collection or many? In 'Core collections of plant genetic resources'.(Eds Hodgkin, T., Brown, A.H.D., van Hintum, Th.J.L., &Morales, E.A.V.) pp. 199–210.

Parra-Quijano, M., Draper, D., Torres, E., & Iriondo, J.M. (2008). Ecogeographical representativeness in crop wild relative *ex situ* collections. In 'Crop Wild Relative Conservation and Use' (Eds Maxted, N., Ford-Lloyd, B.V., Kell, S.P., Iriondo, J., Dulloo, E. & Turok, J.). Wallingford: CABI Publishing, pp. 249–273.

Parra-Quijano, M., Iriondo, J. M., & Torres, E. (2012a). Applications of ecogeography and geographic information systems in conservation and utilization of plant genetic resources. *Spanish Journal of Agricultural Research*, *10*(2), 419-429.

Parra-Quijano, M., Iriondo, J. M., & Torres, E. (2012b). Improving representativeness of genebank collections through species distribution models, gap analysis and ecogeographical maps. *Biodiversity and Conservation*, *21*(1), 79-96.

Tapia, C., Paredes, N., & Lima, L. (2019). Representatividad de la diversidad del género *Musa* en el Ecuador. *Ecuador es calidad: Revista Científica Ecuatoriana*, *6*(1).

Thomas, E., Alcazar, C., Moscoso Higuita, L. G., Osorio, L. F., Salgado-Negret, B., Gonzalez, M., Parra-Quijano, M., Bozzano, M., Loo, J., Jalonen, R., & Ramirez, W. (2017). The importance of species selection and seed sourcing in forest restoration for enhancing adaptive potential to climate change: Colombian tropical dry forest as a model. Secretariat of the Convention on Biological Diversity.

Thormann, I., Endresen, D. T. F., Rubio-Teso, M. L., Iriondo, M. J., Maxted, N., & Parra-Quijano, M. (2014). Predictive characterization of crop wild relatives and landraces. Technical guidelines version 1. Bioversity International, Rome.

Van Zonneveld, M., Scheldeman, X., Escribano, P., Viruel, M. A., Van Damme, P., Garcia, W., Tapia, C., Romero, J., Sigueñas, M., & Hormaza, J. I. (2012). Mapping genetic diversity of cherimoya (Annona cherimola Mill.): application of spatial analysis for conservation and use of plant genetic resources. *PloS one*, *7*(1), e29845.