PGR Secure

Novel characterization of crop wild relative and landrace resources as a basis for improved crop breeding

Project context, overview and links with the UK

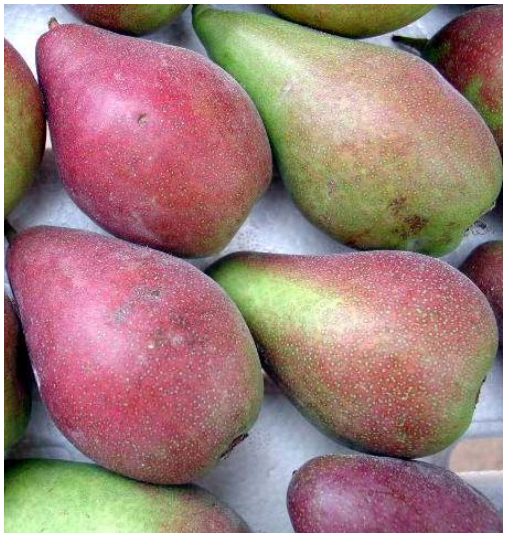
Nigel Maxted, Shelagh Kell, Hannah Fielder and Brian Ford-Lloyd, University of Birmingham, UK

UK PGR Group meeting, 06 October 2011

Overview

- Policy background inc. Horizon Scanning in Madeira
- ECPGR *In Situ* and On-farm Conservation Network
  - PGR Forum
  - AEGRO
- PGR Secure

Policy context



- Convention on Biological Diversity (1992)
- FAO **Global Plan of Action** for the Conservation and Sustainable Utilization of PGRFA (1996)
- The Global Strategy for Plant Conservation (2000) (Target (b) (ix): "**70 % of the genetic diversity of crops …. conserved…..**")
- International Treaty on Plant Genetic Resources for Food and Agriculture (2001)
- Global Strategy for CWR Conservation and Use (2008)
- European Strategy for Plant Conservation (2008)
  - **Establishment of 25 European crop wild relative *in situ* genetic reserves**
  - **Gap analysis review of *ex situ* CWR and LR holdings and gap filling**
  - **Prepare a European inventory of traditional, local crop landrace varieties**
  - **Prepare a priority list of European crop wild relatives**

Policy context

- CBD Strategic Plan agreed in Nagoya (2010) – Target 13 of 20!

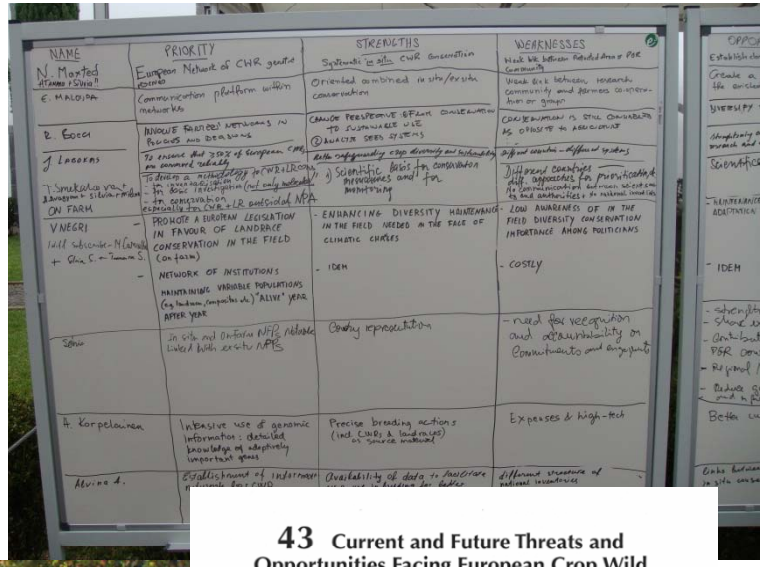
  "Target 13. By 2020, The status of crop and livestock genetic diversity in agricultural ecosystems and of wild relatives has been improved. (SMART target to be developed at global and national levels) …. In addition, *in situ* conservation of wild relatives of crop plants could be improved inside and outside protected areas."

- CBD Global Strategy for Plant Conservation 2011–2020 (2010) Target 9 of 16

  "Target 9: 70 per cent of the genetic diversity of crops including their wild relatives and other socio-economically valuable plant species conserved, while respecting, preserving and maintaining associated indigenous and local knowledge."

Horizon scanning in Madeira

AEGRO / ECPGR *In Situ* and On-farm Conservation Network symposium, *'Towards the establishment of genetic reserves for crop wild relatives and landraces in Europe'* was held at the University of Madeira, Funchal, Portugal 13–17 September 2010



43 Current and Future Threats and Opportunities Facing European Crop Wild Relative and Landrace Diversity

N. Maxted, Z.I. Akparov, M. Aronsson, Å. Asdal, A. Avagyan, B. Bartha, D. Benediková, T. Berishvili, R. Bocci, J. Cop, T. Curtis, K. Daugstad, S. Dias, M.C. Duarte, S. Dzmitryeva, J. Engels, D.A. Fasoula, N. Ferant, L. Frese, P. Freudenthaler, R. Hadas, L. Holly, A. Ibraliu, J.M. Iriondo, S. Ivanovska, T. Jinjikhadze, G. Kamari, S.P. Kell, C. Kik, L. Koop, H. Korpelainen, K. Kristiansen, A. Kyratzis, J. Labokas, L. Maggioni, J. Magos Brehm, E. Maloupa, J.J.R. Martinez, P.M.R. Mendes Moreira, M. Musayev, M. Radun, P. Ralli, D. Sandru, K. Sarikyan, B. Schierscher-Viret, T. Smekalova, Z. Stehno, T. Stoilova, S. Strajeru, A. Tan, M. Veteläinen, R. Vögel, G. Vorosvary and V. Negri

43.1 Introduction

Conservation budgets are increasingly under pressure from alternative demands for funding and, as conservation is largely funded from the State and there are many competing funding demands, there is an imperative to maximize the efficiency of conservation expenditure. Any activity that

2010, was held at the end of the symposium 'Towards the establishment of genetic reserves for crop wild relatives and landraces in Europe', which was the final dissemination meeting of the EC AGRI GENRES 057 project An Integrated European In Situ Management Workplan: Implementing Genetic Reserve and On-farm Concepts (AEGRO). For the *In*

Key results of horizon scanning

Short-term CWR priorities (0–20 years):

1. Establish national and European systematic CWR genetic reserve network
2. Integrate *in situ* CWR conservation into on-farm initiatives
3. Genetic gap analysis to aid national CWR action plans
4. Legislative protection for CWR species and genetic diversity
5. Promotion of conservationist/breeder links

	%		
	Yes	Partial	No
European countries with National CWR action plan	6	25	69
National inventory in place	47	6	47
Genetic reserves established	9	12	79
Systematic *ex situ* conservation	0	94	6

N = 32

Key results of horizon scanning

Short-term LR priorities (0–20 years):

1. Production of national LR inventories
2. Generation and implementation of a National LR Conservation Strategy

	%		
	Yes	Partial	No
European countries with National LR strategy	3	94	3

N = 32

Major limitation in all cases was <u>funding</u>

Key results of horizon scanning

Medium-term CWR priorities (2020–2035):

1. European network of CWR genetic reserves (via Natura 2000 network?)
2. Systematic IUCN Red Listing of European CWR species and genetic diversity threat assessment
3. Promotion of more participatory management and monitoring models
4. Focus national CWR inventories and prioritization to address breeders' demands

Key results of horizon scanning

Medium-term LR priorities (2020–2035):

1. Improved European and national legislation to promote LR on-farm conservation
2. Research unique value of crop diversity held in European home gardens
3. Establish European on-farm inventory of LR, former breeders' varieties and farm-saved seeds
4. Develop participatory LR management and monitoring models
5. Promote biodiversity friendly agricultural systems

ECPGR *In Situ* and On-farm Conservation Network

- ECPGR Steering Committee recommended establishment of *In Situ* and On-farm Conservation Network in Phase V (1999)
- 1st Network and two Task Forces met in Isola Polvese, Italy, May 2000
- 2nd Meeting of On-Farm Task Force, June 2006, Stegelitz, Germany
- 3rd Meeting of On-Farm Task Force, October 2007, Ljubliana, Slovenia (Home Gardens in Europe)
- *In Situ* / On-farm conservation a priority for ECPGR Phase VIII (2009)
- Task Forces upgraded to Working Groups
- 1st Network and two Working Group meetings in Madeira, Portugal Sept 2010

ECPGR *In Situ* and On-farm Conservation Network

- Major achievements:
  - Raising professional and public awareness
  - Specific projects
    - PGR Forum
    - AEGRO
    - PGR Secure
  - Publication of methodologies

PGR Forum

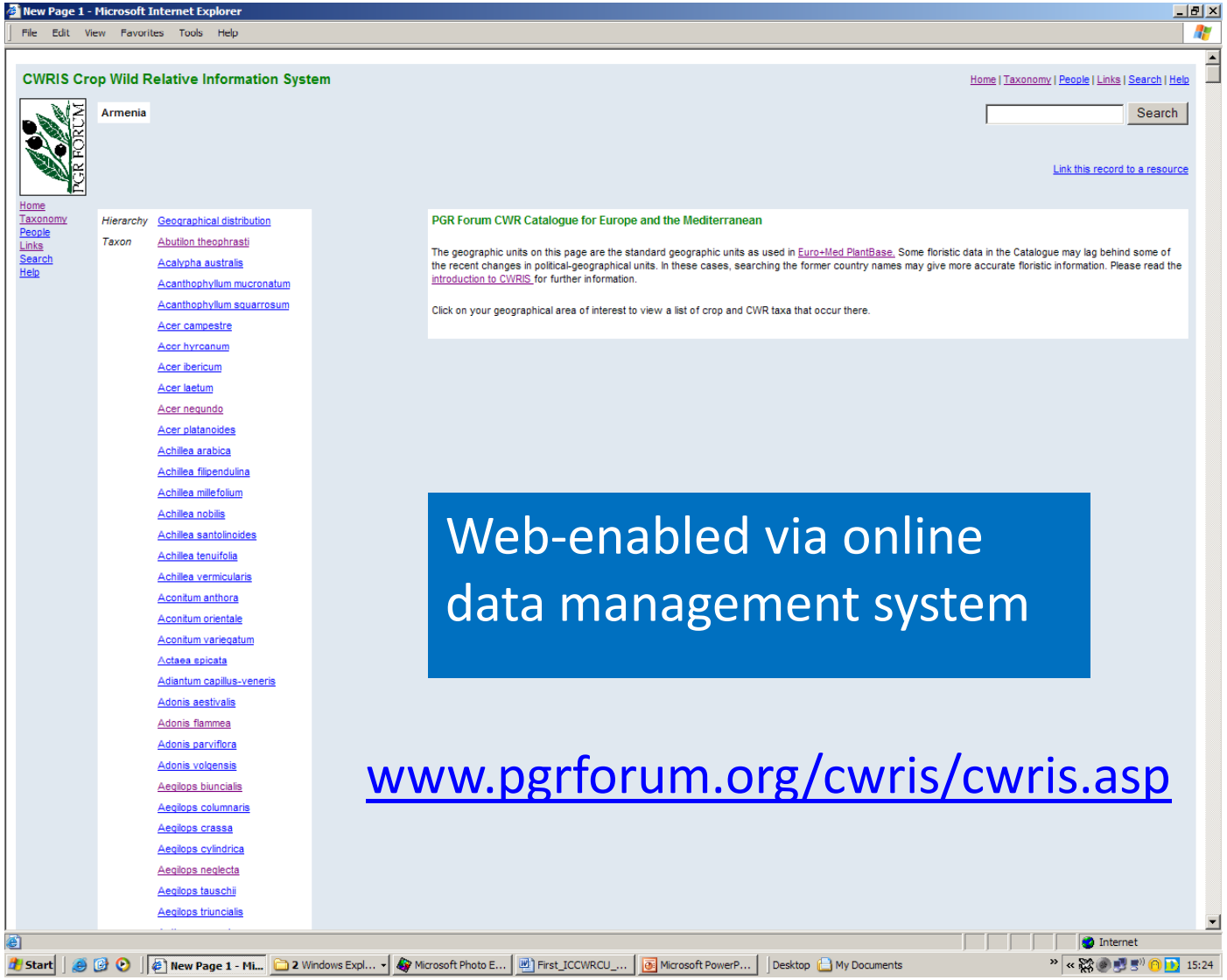
www.pgrforum.org

European crop wild relative diversity assessment and conservation forum

- An EC Framework 5 funded Thematic Network
- 23 partner institutes + advisory and stakeholder panels
- € 733,700; 36 months from November 2002

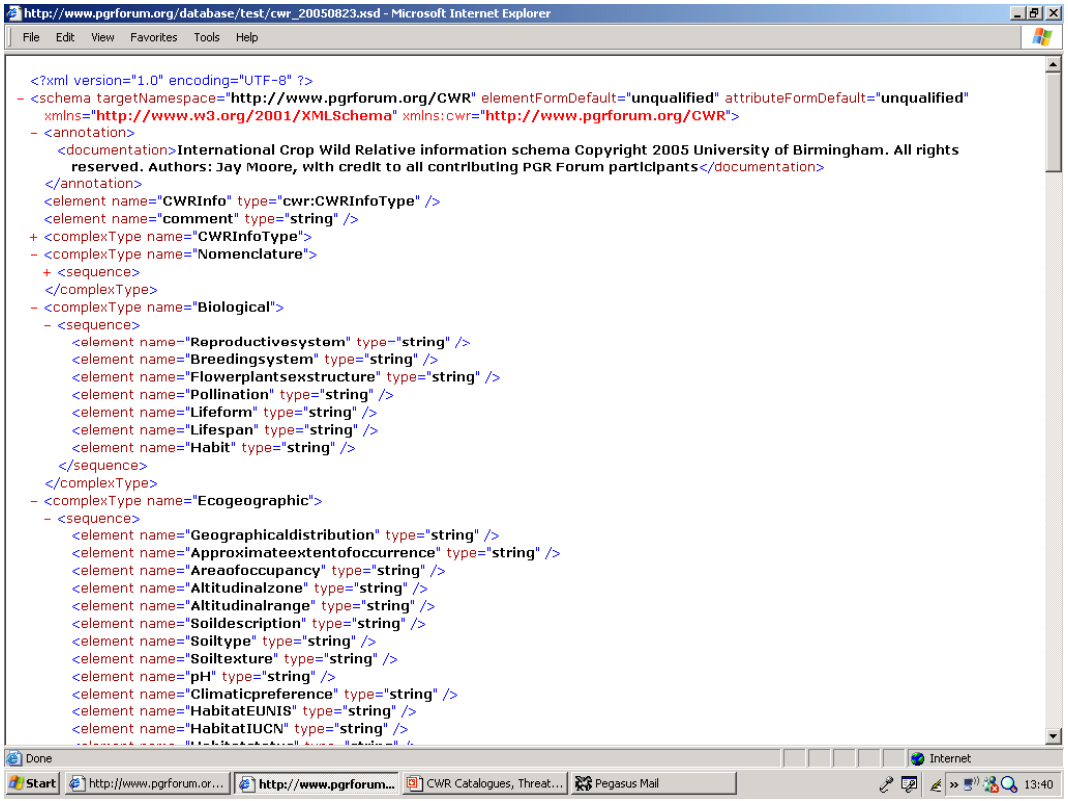
- European forum to debate methodologies for the conservation of CWR, with a focus on *in situ* conservation

CWR Catalogue for Europe and the Mediterranean



Data structure and documentation methodology

Crop Wild Relative Information System (CWRIS)



CWRML (XML Schema) (www.pgrforum.org/CWRML.htm)

Moore, J.D., et al. (2008). CWRML: representing crop wild relative conservation and use data in XML. *BMC Bioinformatics*, 9: 116.

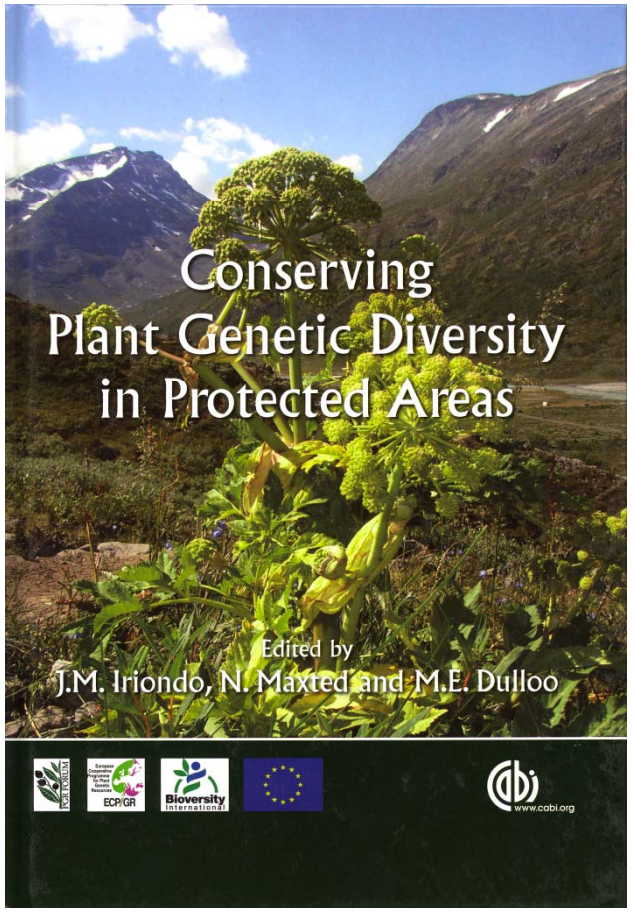
Population *in situ* management and monitoring methodology

Iriondo, J., Maxted, N. and Dulloo, E., (2008b). *Conservation plant genetic diversity in protected areas*. CAB International, Wallingford.

7 papers by 16 authors

Covering:

1. Introduction
2. Genetic reserve location and design
3. Genetic reserve management
4. Population monitoring methodologies for the *in situ* genetic conservation of CWR
5. Population and habitat recovery techniques
6. Complementary *in situ* / *ex situ* strategies
7. Final consideration



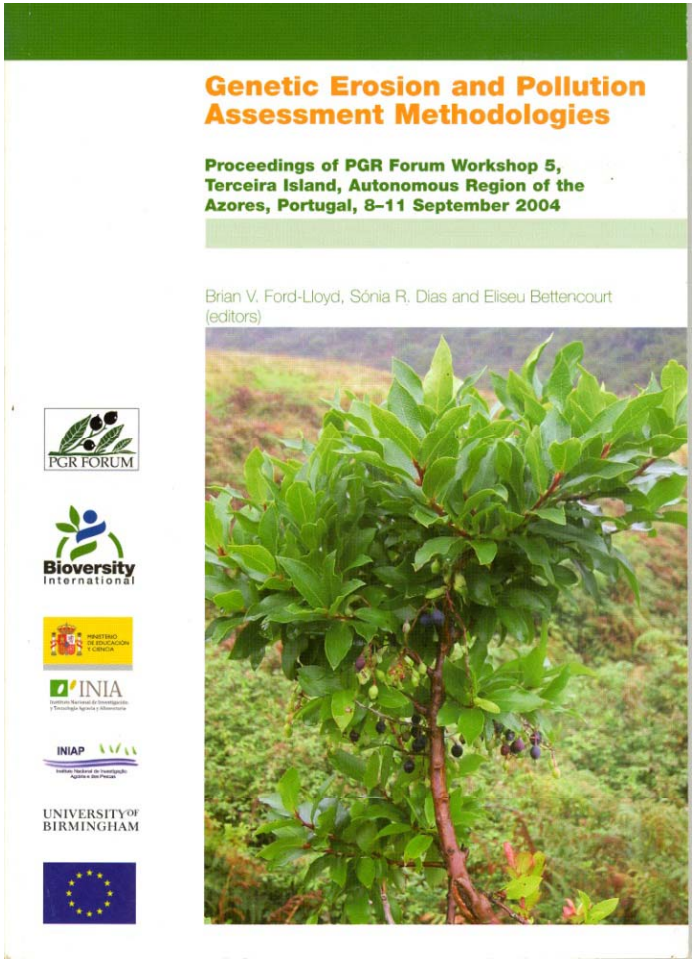
Genetic erosion and genetic pollution assessment methodology

Ford-Lloyd, B.V., Dias, S.R. & Bettencourt, E. (2006). *Genetic erosion and pollution assessment methodologies*. IPGRI, Rome.

12 papers by 36 authors

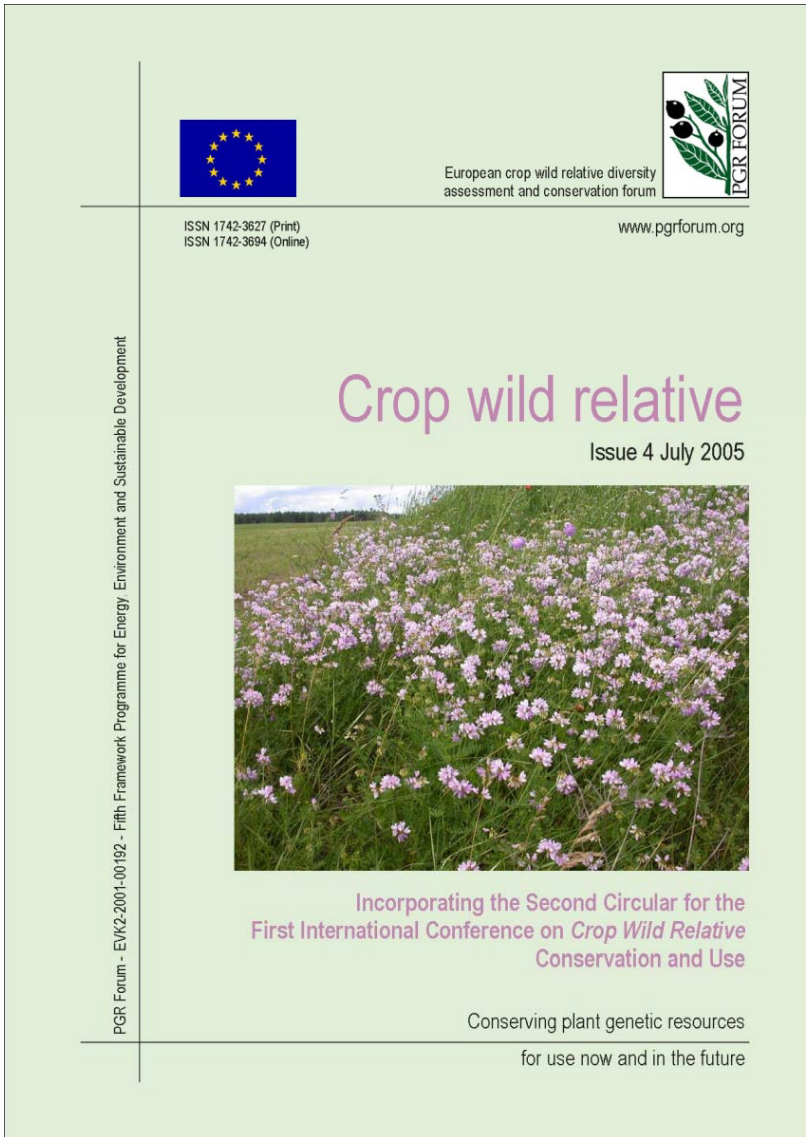
Covering:

- Risk assessment and gene flow
- Genetic erosion and pollution
- Molecular approaches to genetic assessment
- Case studies for forage plants, grassland, cotton, fruit and forest trees



Increased national European CWR capacities

- Crop wild relative newsletter (7 issues)
- Various methodologies and case studies are either published or in the process of publication on the website / journals
- CWR public and professional awareness raised
- Stimulation of National PGR Programme in CWR related activity (e.g,. selection of 5 ‘top’ CWR reserves in Ireland and the UK)



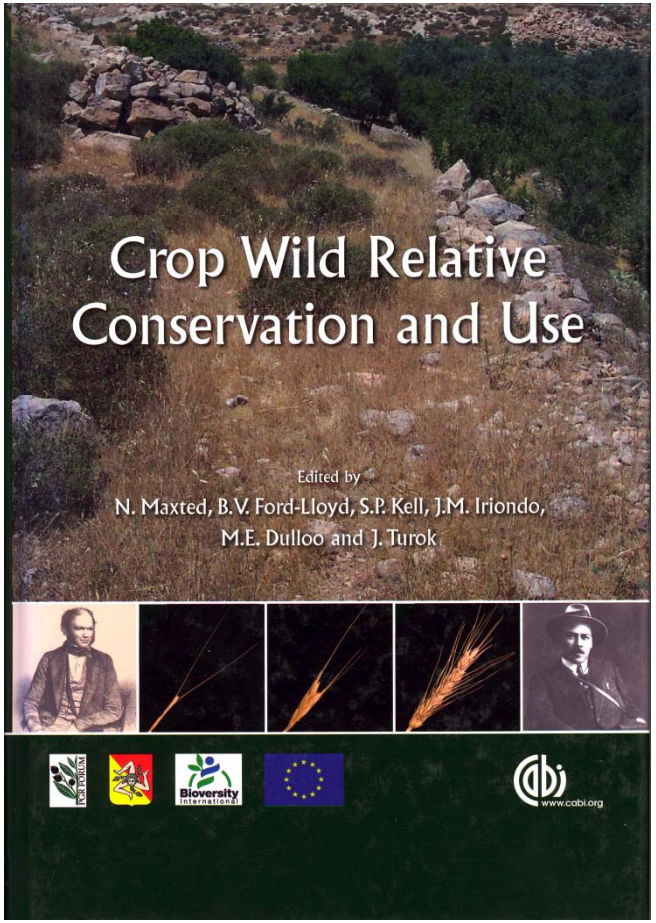
First International Conference on Crop Wild Relative Conservation and Use – Sicily, September 2005

Maxted, N., Ford-Lloyd, B.V., Kell, S.P., Iriondo, J., Dulloo, E. and Turok, J., (2008). *Crop wild relative conservation and use*. CAB International, Wallingford.

49 papers by 128 authors

Covering:

1. Crop wild relative conservation and use: an overview
2. Establishing inventories and conservation priorities
3. Threat and conservation assessment
4. Genetic erosion and genetic pollution
5. *In situ* conservation
6. *Ex situ* conservation
7. Information management
8. Gene donors for crop improvement
9. Use of crop wild relatives and underutilized species
10. Global issues in crop wild relative conservation and use

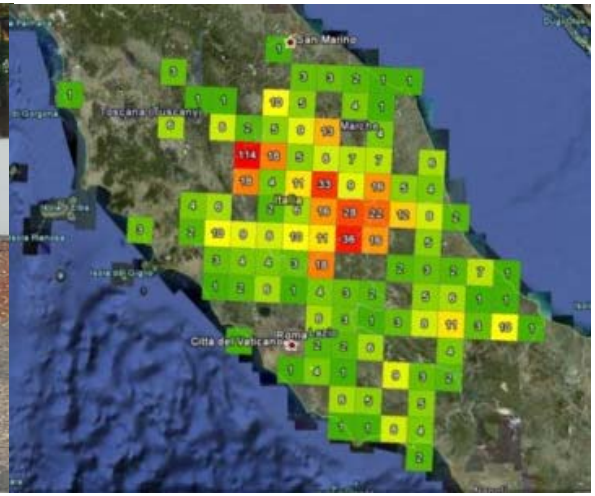


AEGRO – An integrated *in situ* management work plan: implementing genetic reserve and on-farm concepts

- Targeted Action within the framework of Council Regulation 870/2004 establishing a Community programme on genetic resources in agriculture
- Regional *in situ* conservation strategies developed for 3 crop gene pools + *Prunus avium*
- CWRIS-PLIS (Population Level Information System)

AEGRO

- Methodologies for the identification of genetic reserves and on-farm conservation sites
- AEGRO / ECPGR *In Situ* and On-farm Conservation Network symposium held in Madeira, September 2010
- Proceedings published by CABI December 2011



KBBE.2010.1.1-03: Characterisation of biodiversity resources for crop wild relatives to improve crops by breeding

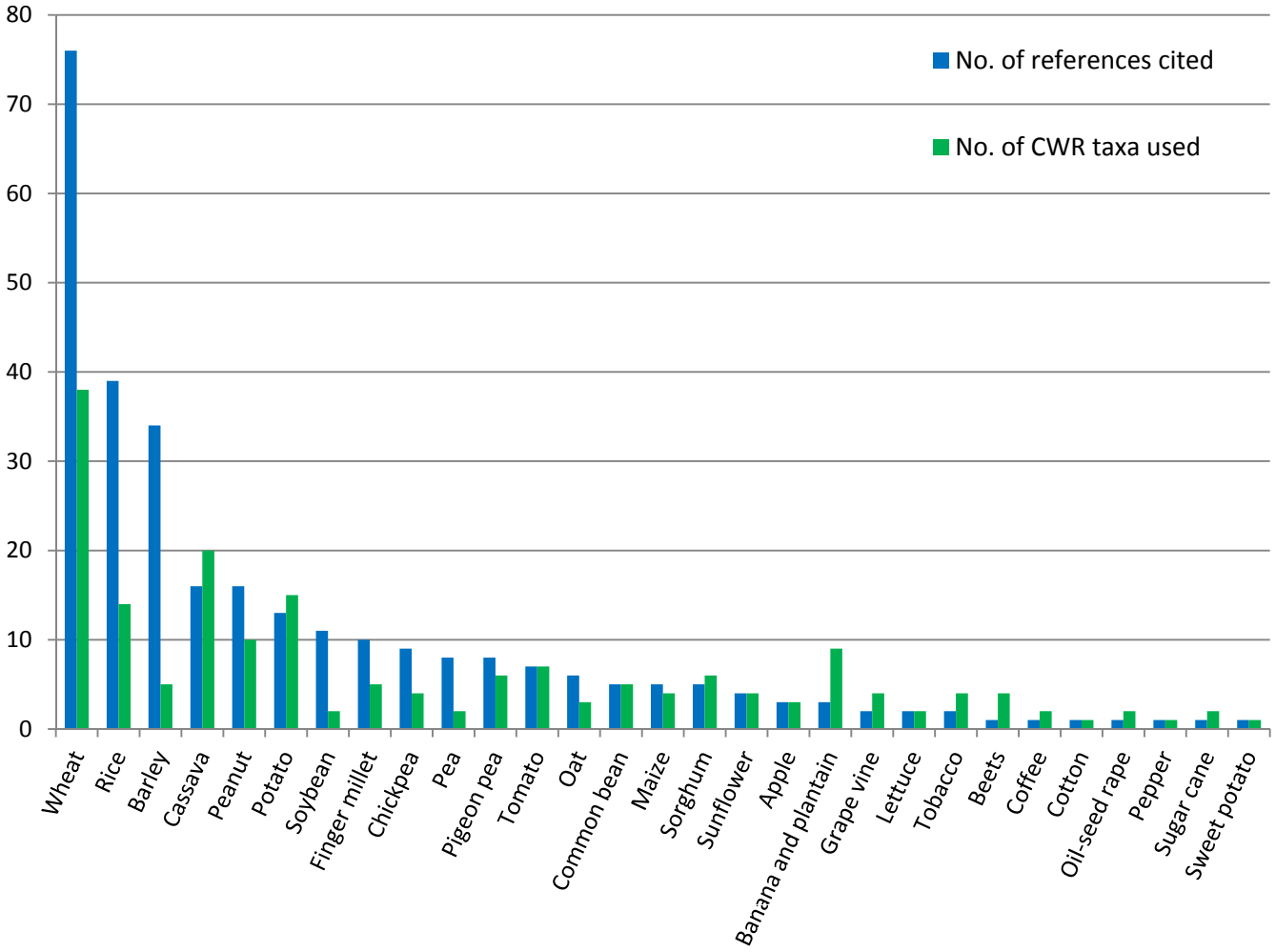
Call Text

Starting from a systematic assessment of crop wild relatives and local varieties genetic resources in Europe the proposed project will further develop tools, methods and procedures to expand the characterisation of crop wild relatives and local varieties and create a comprehensive phenotypic and genotypic inventory of these genetic resources. The phenotypic and genotypic information shall be of use in breeding programmes for relevant crops in Europe such as cereals, grain legumes, forage and vegetables. In addition, the project will identify relevant management interventions to secure and improve the in-situ and ex-situ conservation of crop wild relatives and local varieties. This is particularly important in view of the expected impact of climate change on genetic resources.

Traits already transferred from CWR to wheat

Aegilops tauschii	Rust
Ae. tauschii	Sprouting suppression
Ae. tauschii	Wheat soil-borne mosaic virus, wheat spindle-streak mosaic virus
Ae. tauschii	Agronomic traits, yield improvement
Ae. tauschii, T. turgidum	Yellow rust and leaf rust
Ae. tauschii, T. turgidum	Water-logging tolerance
Ae. variabilis	Powdery mildew resistance
Ae. variabilis	Root-knot nematode resistance
Ae. ventricosa	Cyst nematode resistance
Ae. ventricosa	Eye spot resistance
Agropyron elongatum, Ae. umbellulata	Leaf and stem rust resistance
Ag. elongatum	Drought tolerance
Agropyron sp.	Frost resistance
Secale cereale	Yield improvement
Triticum dicoccoides, T. timopheevii, T. monococcum, Ae. speltoides	*Fusarium* head blight
T. monococcum	Stem rust
T. turgidum subsp. dicoccoides	Protein quality improvement
T. turgidum subsp. dicoccoides	Powdery mildew
T. turgidum subsp. dicoccoides	Stem rust
T. urartu	Powdery mildew
Thinopyrum bessarabicum	Salt resistance
Th. intermedium, Th. ponticum	Barley yellow dwarf virus, wheat streak mosaic virus
Th. ponticum	*Fusarium* head blight resistance

The value of CWR for crop improvement



Citations:

- 2% <1970
- 13% 1970s
- 15% 1980s
- 32% 1990s
- 38% >1999

Use:

- 39% pest resistance
- 17% abiotic stress resistance
- 13% yield increase

Data source: Maxted and Kell (2009)

US$ 115 billion toward increased crop yields per year worldwide (Pimentel *et al.*, 1997)

PGR Secure – Novel characterization of crop wild relative and landrace resources as a basis for improved crop breeding

www.pgrsecure.org

Aim:

To research novel characterization techniques and conservation strategies for European crop wild relative and landrace diversity, as a means of enhancing crop improvement by breeders, so ensuring continued food security in the face of changing consumer demand and climate change

PGR Secure: Project partners

Partner	Organization	Country
1	University of Birmingham	UK
2	Dienst Landbouwkundig Onderzoek (DLO)	NL
3	Bioversity International	International
4	Universita Degli Studi Di Perugia	IT
5	Julius Kühn-Institut Bundesforschungsinstitut fur Kulturpflanzen (JKI)	DE
6	Nordiskt Genresurscenter (NordGen)	Regional
7	Maa- ja Elintarviketalouden Tutkimuskeskus (MTT)	FI
8	Universidad Rey Juan Carlos	ES
9	ServiceXS BV (Private biotechnology company)	NL
10	University of Nottingham	UK
11	EUCARPIA	HU
+	European plant breeders	
+	ECPGR *In Situ* and On-Farm Conservation Network	
+	In Situ and On-Farm NFPs	

PGR Secure concept

The concept of PGR Secure is to:

a. improve breeders' use of conserved CWR / LR diversity

b. enhance CWR / LR diversity availability through the systematic conservation of CWR and LR species and genetic diversity

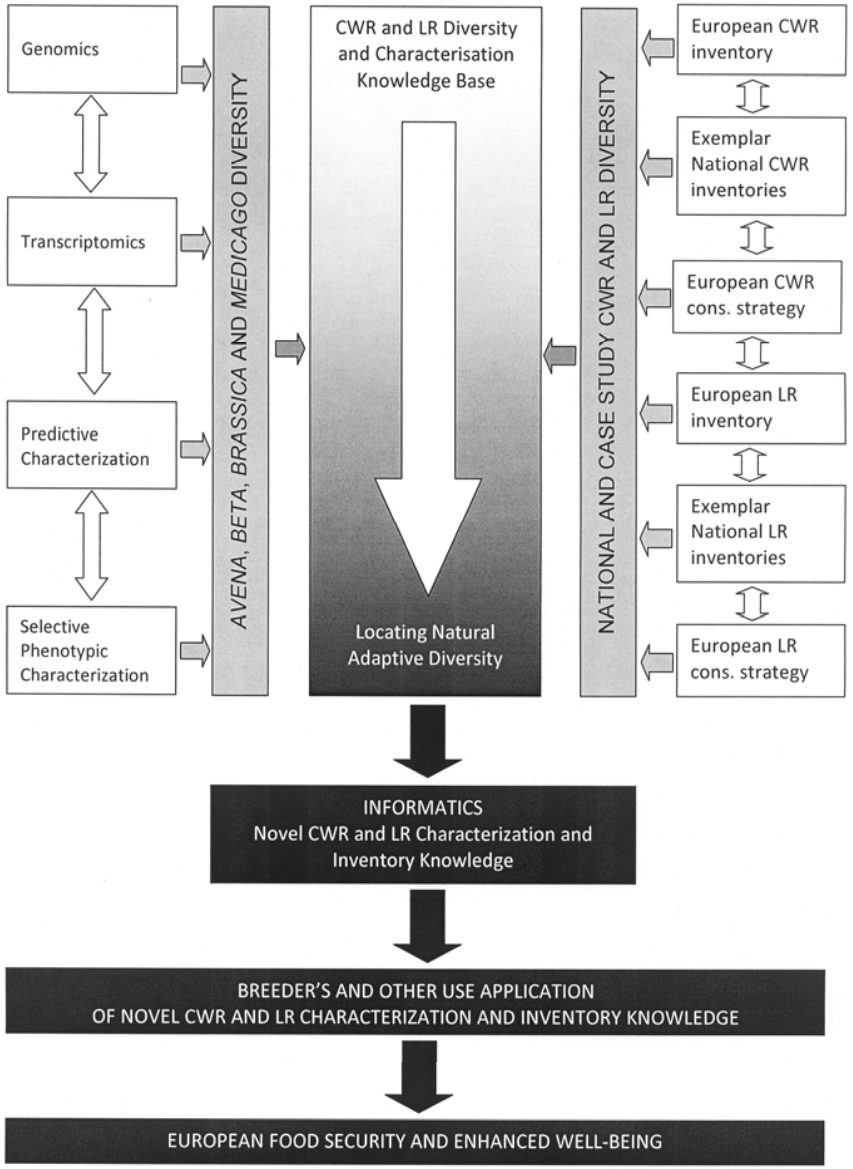
To achieve these dual goals the project has four research themes:

i. Novel characterization techniques

ii. CWR and LR conservation

iii. Improved breeders' use

iv. Informatics



PGR Secure workpackages

1	Phenomics, genomics and transcriptomics	• Demonstrate how novel phenomics, genomics and transcriptomics tools can be used to speed up plant breeding • Insect resistance in brassica crops as a case study
2	Informatics	• Produce a web-based Trait Information Portal to provide access to CWR and LR trait data • Predictive characterization (FIGS) to identify populations of CWR + LR with adaptive traits for insect resistance (*Brassica* and *Medicago* as case studies)
3	Crop wild relative conservation	• Produce national and Europe-wide CWR inventories • National CWR conservation strategy case studies for the UK, Finland, Italy and Spain • Develop a European CWR conservation strategy for priority crop gene pools • Produce a generic European CWR conservation strategy combining the regional and national approaches

PGR Secure workpackages

4	Landrace conservation	• Gain an understanding of the diversity of European LR and their present conservation status • Develop a systematic European LR conservation strategy to promote their use by breeders and by local communities and farmers
5	Engaging the user community	• Promote the use of CWR and LR in Europe • Consultation with stakeholders (gene bank managers, breeding companies, public research bodies, NGOs), SWOT analysis to identify constraints in CWR + LR use • Promote the flow of pre-breeding material and information gained in the project to stakeholders
6	Dissemination and training	• Website, web-enabled inventories, TIP, publications, workshops, dissemination conference
7	Project management	

PGR Secure: Links

- National links
  - National or nationally based breeding companies
  - National PGR Programmes
  - National PA Networks
- European links
  - European based breeding companies
  - EUCARPIA network (http://www.eucarpia.org/).
  - ECPGR crop networks and 53 *European Central Crop Databases* ECCDB
  - ECPGR *In Situ* and On-farm Conservation Network
  - ECPGR Documentation and Information Network
  - EC GenRes Projects, such as AEGRO (http://aegro.bafz.de/)
  - EC FP7 EUROPLANTGENES (in prep.)
- International links
  - International based breeding companies
  - International agencies: Global Environment Facility, the Food and Agriculture Organization of the United Nations, the Global Crop Diversity Trust and Bioversity International
  - Specific projects e.g. Global Crop Diversity Trust supported CWR Project
  - IUCN Species Survival Commission Crop Wild Relative Specialist Group
  - FAO commissioned 'Establishment of a global network for the *in situ* conservation of crop wild relatives: status and needs'
  - Other bilateral projects e.g. SAIN UK/China supported project 'Conservation for enhanced utilization of crop wild relative diversity for sustainable development and climate change mitigation'

PGR Secure: Anticipated results

- Improved conventional and marker assisted molecular approaches to characterization / evaluation
- Examples of exploiting transcriptome for adaptive trait recognition
- Trait information portal of characterization / evaluation data
- FIGS approach to germplasm identification (initially demonstrated only in wheat for powdery mildew resistance genePm3)
- National CWR conservation strategy case studies for Finland, Italy, Spain and UK + others?
- Development of national CWR conservation strategies by the ECPGR *In Situ* Conservation Network
- European CWR conservation strategy

PGR Secure: Anticipated results

- Partial European LR inventory
- National LR inventories for Finland, Italy and UK + others?
- Development of national LR conservation strategies by the ECPGR *In Situ* Conservation Network
- Breeders working interactively with agrobiodiversity conservationists
- Anecdotal evidence of how breeders find and use conserved agrobiodiversity
- Strengthened linkage between agrobiodiversity conservationist and breeder communities
- Improved access to CWR and LR data via EURISCO
- Integration of stand-alone ECCDBs, EURISCO and CWRIS information systems

Longer term impacts

- Significantly increase information on important traits in CWR and LR
- Improve access and wider use of biodiversity resources in breeding programmes
- Direct involvement of plant breeders to ensure effective take-up of research results
- More effective use of PGR in European farming

- Address issues of consumer demand and food security and also contribute to the goals of the EC Biodiversity Action Plan for Agriculture
- Refine national and European strategies for sustainable PGRFA conservation

Developing methodologies for the genetic conservation of UK crop wild relatives

Objective:

To secure and improve the *in situ* and *ex situ* conservation of UK CWR diversity through the development of systematic UK CWR conservation actions as a means of underpinning future food security

Hannah Fielder

UNIVERSITY OF BIRMINGHAM

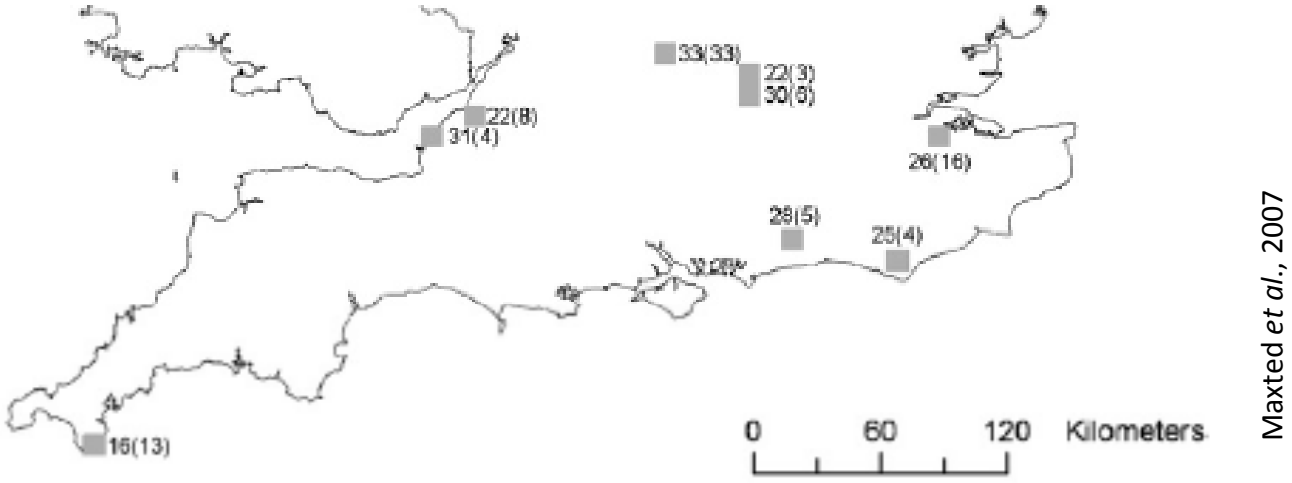
1 National conservation actions

National conservation proposals will be developed to maintain diversity of CWR across the UK

- **Prioritization of CWR** using the revised UK national CWR inventory
- Collation of national datasets for **ecogeographic analysis**
- **GIS gap analysis** to identify priority habitats/sites requiring active conservation or collection
- Proposal of **conservation actions** for CWR both *in situ* and *ex situ*
- Work with **national agencies** to develop and implement appropriate conservation actions (Natural England, SNH, CCW, DARD)

2 The Lizard NNR, Cornwall

- The Lizard is rich in CWR (Maxted *et al*., 2007)
- Aim to establish the 1st European CWR genetic reserve
- This will involve:
  - **Genetic diversity analysis** of CWR taxa on the Lizard
  - **Measurement of genetic distance** between UK populations and those on the Lizard
  - Analysis of current **management actions** on the Lizard
  - Proposals for **novel and revised management actions**



Maxted *et al*., 2007

3 Conservation outside protected areas

- CWR often associated with **disturbed habitats** (e.g., field margins)
- Assess current management and identify priority habitats
- Develop proposals for appropriate management in collaboration **with stakeholders**

4 Next Generation Sequencing (NGS)

- Does **ecogeography** accurately infer underlying genetic diversity?
- NGS allows direct **analysis of genetic distance** between intra-specific CWR populations and accessions
- Results in efficient **targeted collecting**

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UK PGR Group meeting, 06 October 2011