UNIVERSITY OF BIRMINGHAM

PRO-GRACE
PROMOTING A PLANT GENETIC RESOURCE COMMUNITY FOR EUROPE

GRACE RI Pillar 2: *In situ* conservation – overview and networking

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Chania (Greece), 7-10th October 2025

Model of PGR Conservation

Definition of plant genetic resources: "Genetic material of plants which is of value as a resource for the present and future generations of people." (IPGRI, 1993)

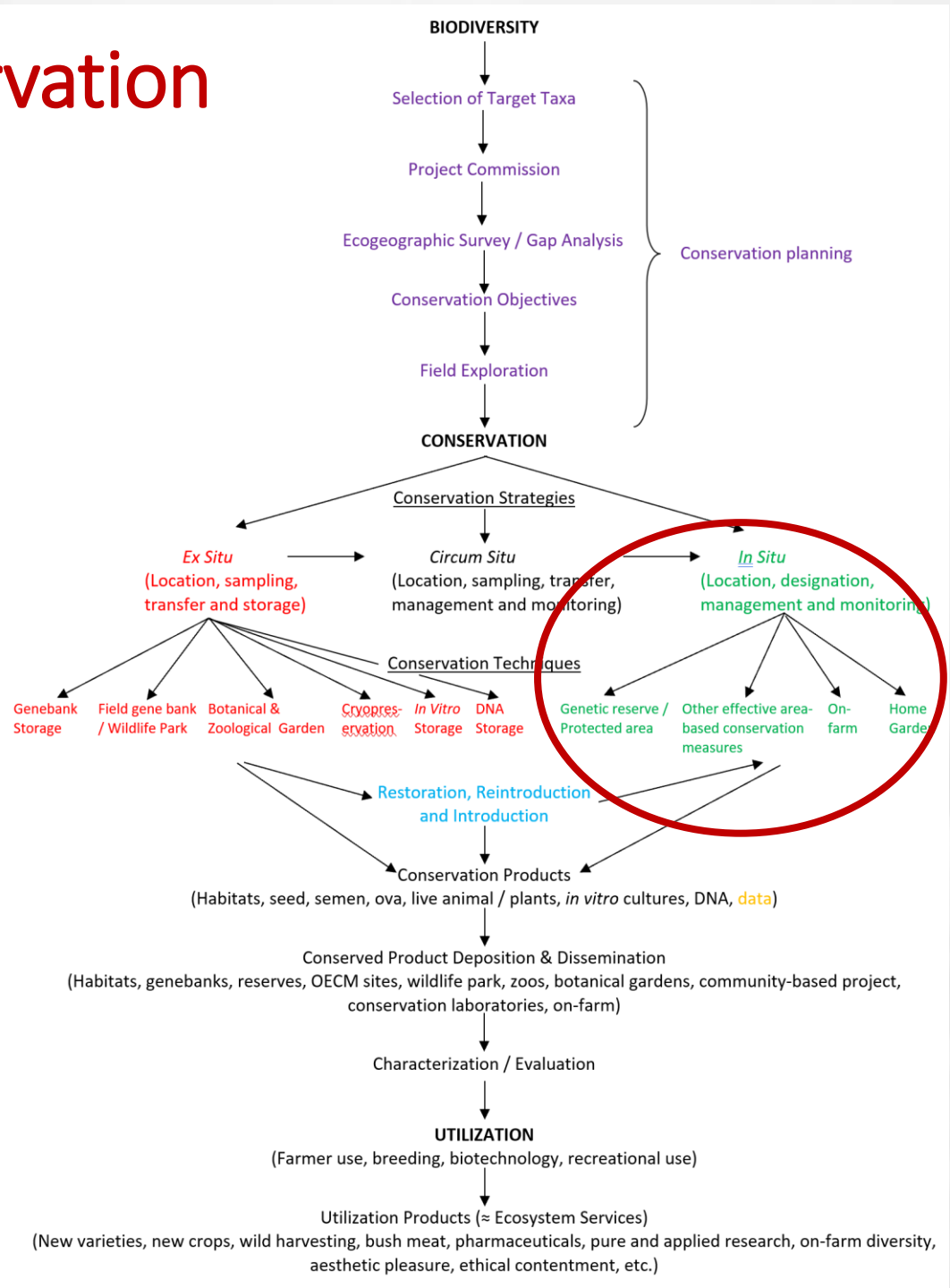
Aim = *Principles of PGR Conservation and Use Congruence*

- *long-term, sustainable maintenance of PGR taxonomic and genetic diversity,*
- *active conservation and characterization of crop, varietal and related wild taxon diversity using complementary techniques,* and
- *conserved resource documentation and availability for utilisation within the applicable legislative context*.

Maxted *et al.* (2025)

Differ to biodiversity conservation by

a. maximizing genetic diversity conserved, and
b. link conserved resource to utilization



Conservation Strategies

- Definition of *ex situ* and *in situ* conservation CBD (1992) Article 2:

"*Ex situ conservation* means the conservation of components of biological diversity outside their natural habitats"

= Location, sampling, transfer and storage

"*In situ conservation* means the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings / and, in the case of domesticates or cultivated species, in the surroundings where they have developed their distinctive properties."

= Location, designation, management and monitoring

Conservation Techniques

Strategies	Techniques	Definition	
In situ conservation	Protected area (genetic reserve) conservation	The location, management and monitoring of (genetic) diversity in natural wild populations within defined areas formally designated for active, long-term conservation.	CWR
	Other effective area-based conservation measures (OECM)	The location, management and monitoring of genetic diversity of natural wild populations in informally managed *in situ* conservation sites.	CWR
	On-farm conservation	The sustainable management of genetic diversity of locally developed traditional crop varieties by farmers within traditional agricultural, horticultural or agri-silvicultural cultivation systems.	LR
	Home garden conservation	The sustainable management of genetic diversity of locally developed traditional crop varieties by individuals in their back-yard gardens.	LR

Why conserve?
Threats to agrobiodiversity

- Replacement of traditional by modern varieties/breeds
- Unsustainable agricultural intensification
- Changes in Land use, urbanization, etc.
- Increased human population (8.24B in 2025), demand for food and other resources
- Human poverty / starvation (744M people are malnourished (FAO, 2024)
- Land degradation (desertification, etc.)
- Social, economic and environmental change (move country to cities)
- Climate change

Decreasing bull fighting causes loss of CWR diversity!

Evergreen oak habitat in the Iberian Peninsula (Portuguese *montados* or Spanish *dehesas*)

Why conserve?

UN Sustainable Development Goals : 2030 targets

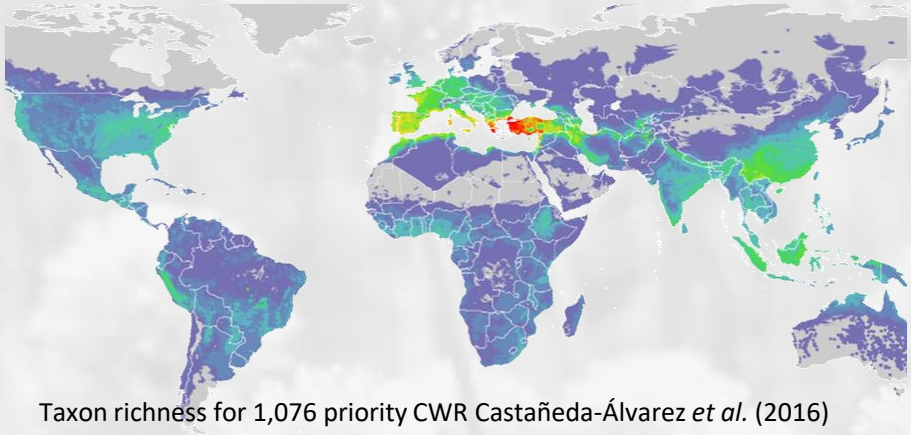
"UN Sustainable Development Goals (UN DESA, 2023) highlighted the need of eradicating extreme poverty and hunger; goals 1, 2 and 3, but particularly 2.5 aims that: *By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels ….* "

= Food Security (Animal Genetic Resources & Plant Genetic Resources + Forest GR, Fish GR, Insect GR, Microbial GR)

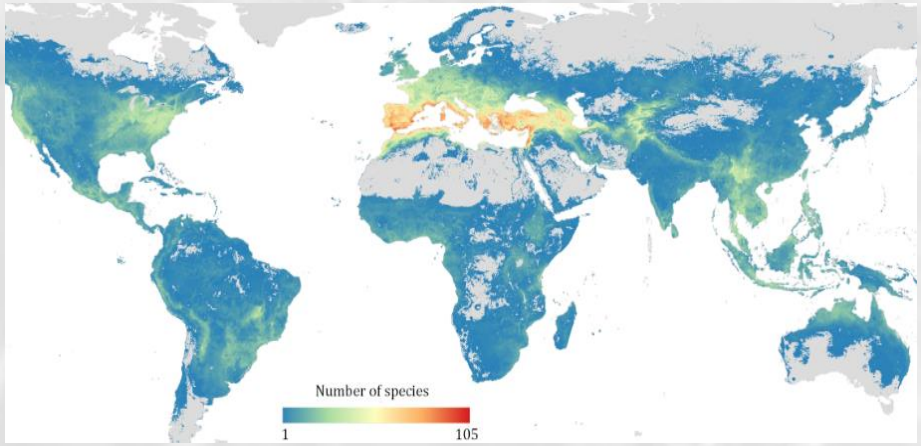
OECM micro-reserve (genetic reserve) Valencia, Spain

Why conserve CWR?

Why now?



Taxon richness for 1,076 priority CWR Castañeda-Álvarez *et al.* (2016)



Taxon richness for 1,394 priority CWR - Vincent *et al.* (2019)

- Conserve threatened resources in a globally important hotspot
- Meet breeders' need for more diversity to adapt to climate change
- Fill the conservation gaps
- Re-focus *ad hoc* PGR activities at regional and national levels
- Meet policy and legislative obligations (SDGs, GPA, CBD, European Green Deal)
- Build on the scientific knowledge foundation established by the Working Groups of the European Cooperative Programme for Plant Genetic Resources (ECPGR)
- CWR conservation in Europe is critical at global level, Mediterranean and West Asian diversity is the PGR hotspot

Why conserve?

CWR already widely used in breeding

CWR	Trait
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. ponticum	*Fusarium* head blight resistance
Thinopyrum sp.	Greenbug resistance

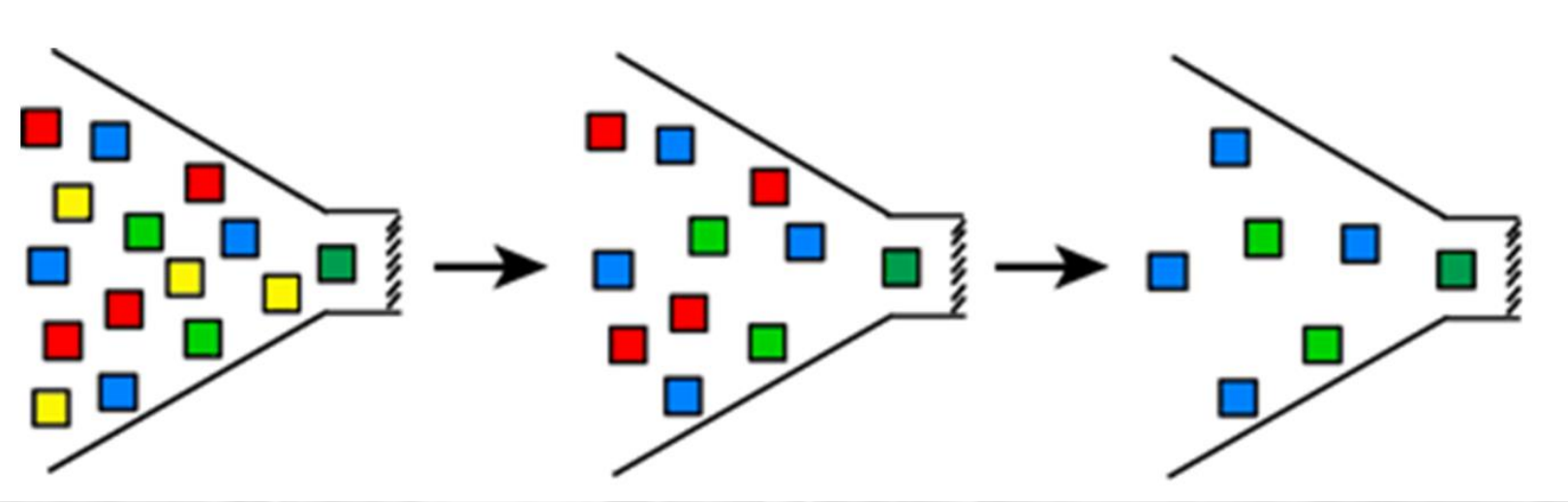
Aegilops speltoides (B-genome)

Wheat

$115 billion toward increased crop yields per year (Pimentel *et al.*, 1997; PWC, 2013 for 29 crops)

Why conserve PGR?

To make available **Genetic diversity**



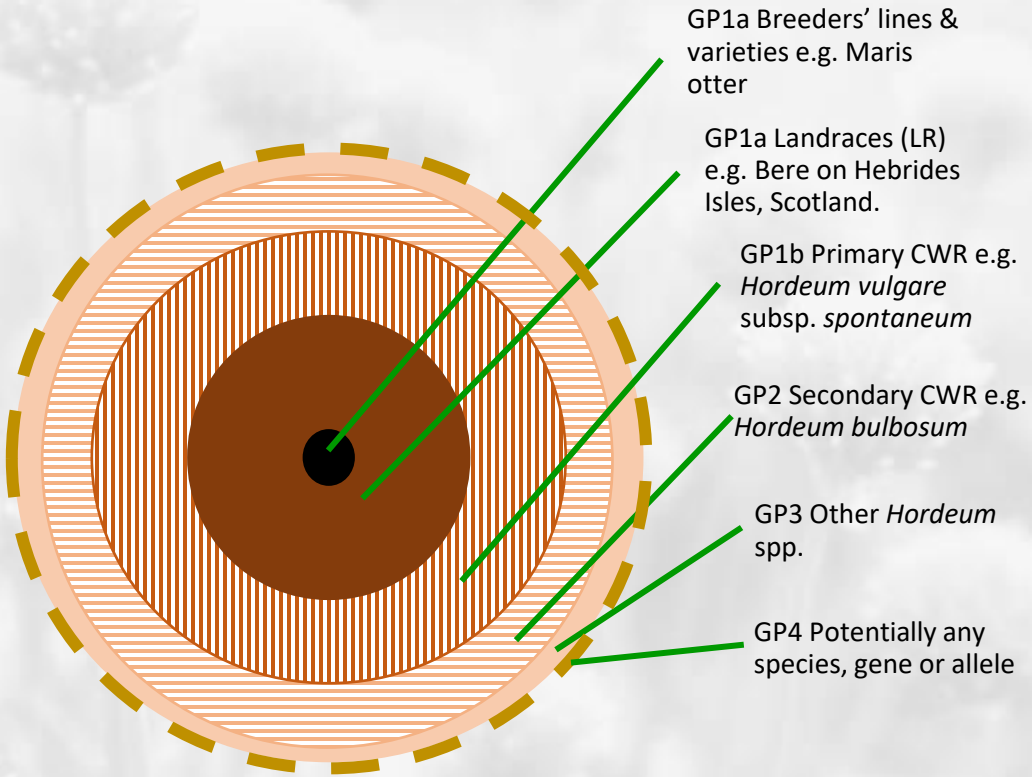
Wild species Landraces Modern varieties

Domestication = loss of genetic diversity …. For tomato 95% of genetic diversity in gene pool is located in wild *Lycopersicon* / *Solanum* spp. (Tanksley and McCouch, 1997)

Why conserve PGR?

To make available **Genetic diversity**

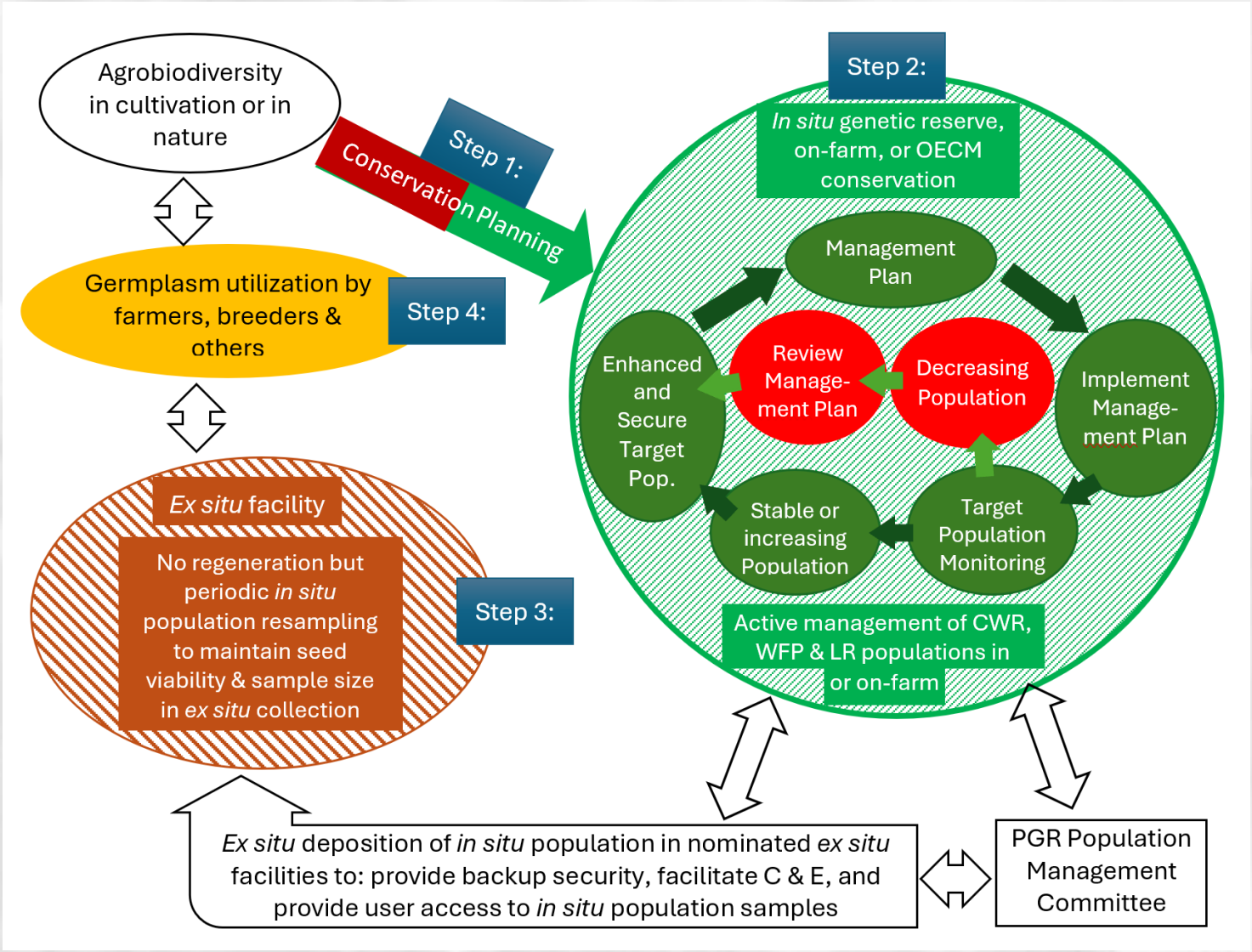
- **Crop wild relatives** (CWR) are wild plant species closely related to crops, including wild ancestors
- **Crop landraces** (LR) are varieties of domesticated crops that are maintained by seed saving, they have historical origin, distinct identity and lack formal crop improvement, as well as often being genetically diverse, locally adapted and associated with traditional farming or cultural practices
- CWR and LR both have (direct and) indirect use as gene donors for crop improvement due to their relatively close genetic relationship to crops and high level of genetic diversity as they have not gone through the domestication 'bottle neck' causing loss of diversity
- Definitions (Maxted *et al.,* 2020)



Usable relative genetic diversity held at each level of the barley genepool, but ≈95% of diversity in CWR and LR

GRACE RI: Pillar 2 *In situ* conservation

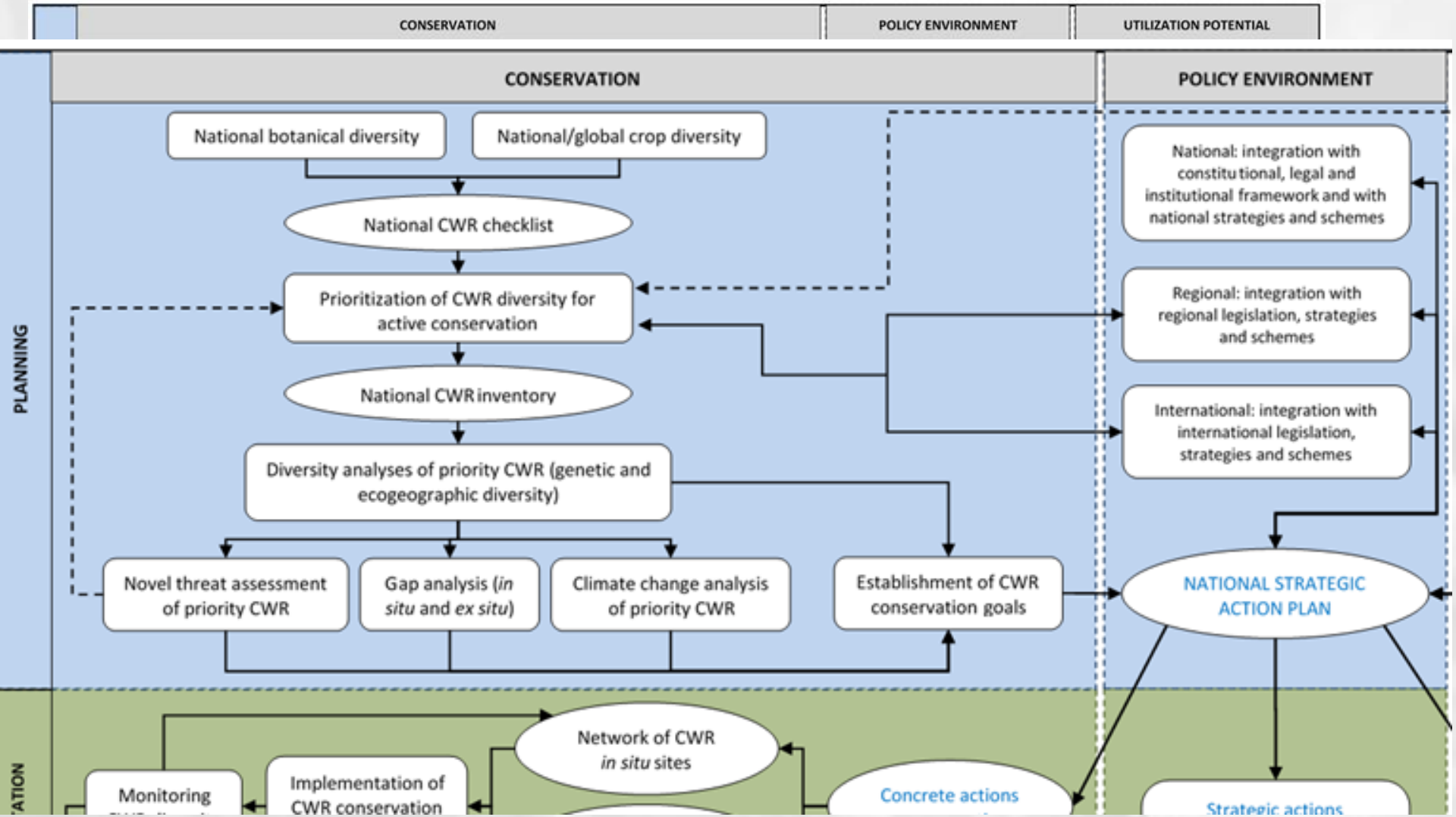
Basic Model



Maxted *et al.* (2024)

GRACE RI: Pillar 2 *In situ* conservation

Step 1 – Conservation planning



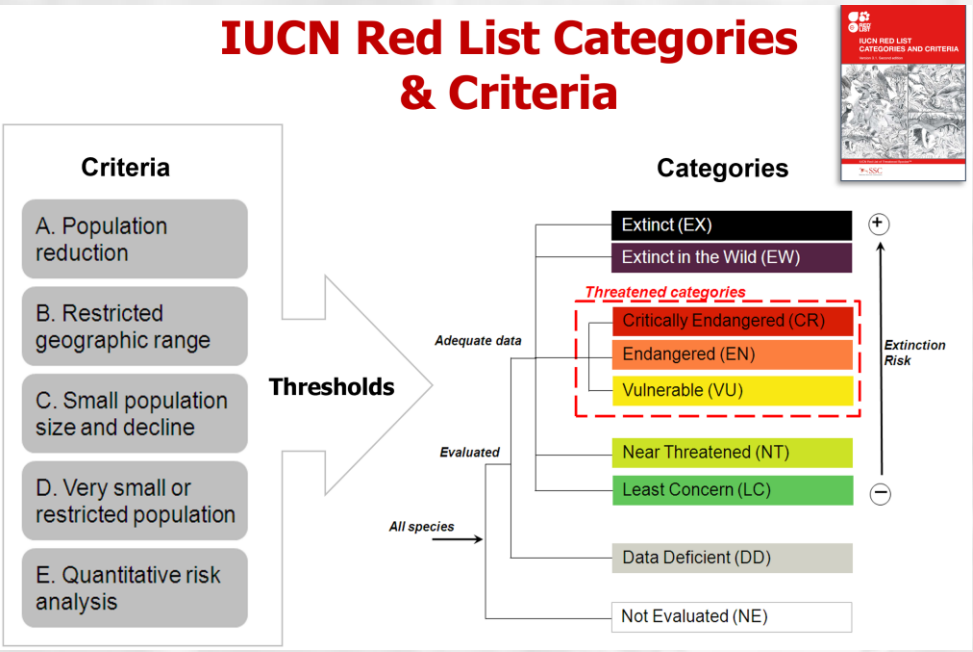
Magos Brehm *et al.* (2017)

Why conserve PGR?

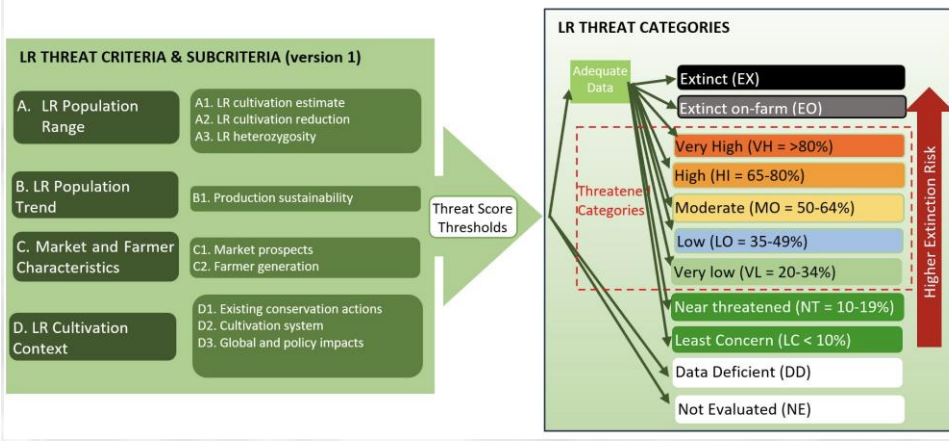
To prioritise threatened diversity's conservation

CWR threat assessment

LR threat assessment



IUCN (2021)



Almeida *et al.* (2024)

Bottom Line -

16-38% of CWR threatened
Maxted *et al.* (2025)

75-95% of LR threatened
Maxted *et al.* (202?)

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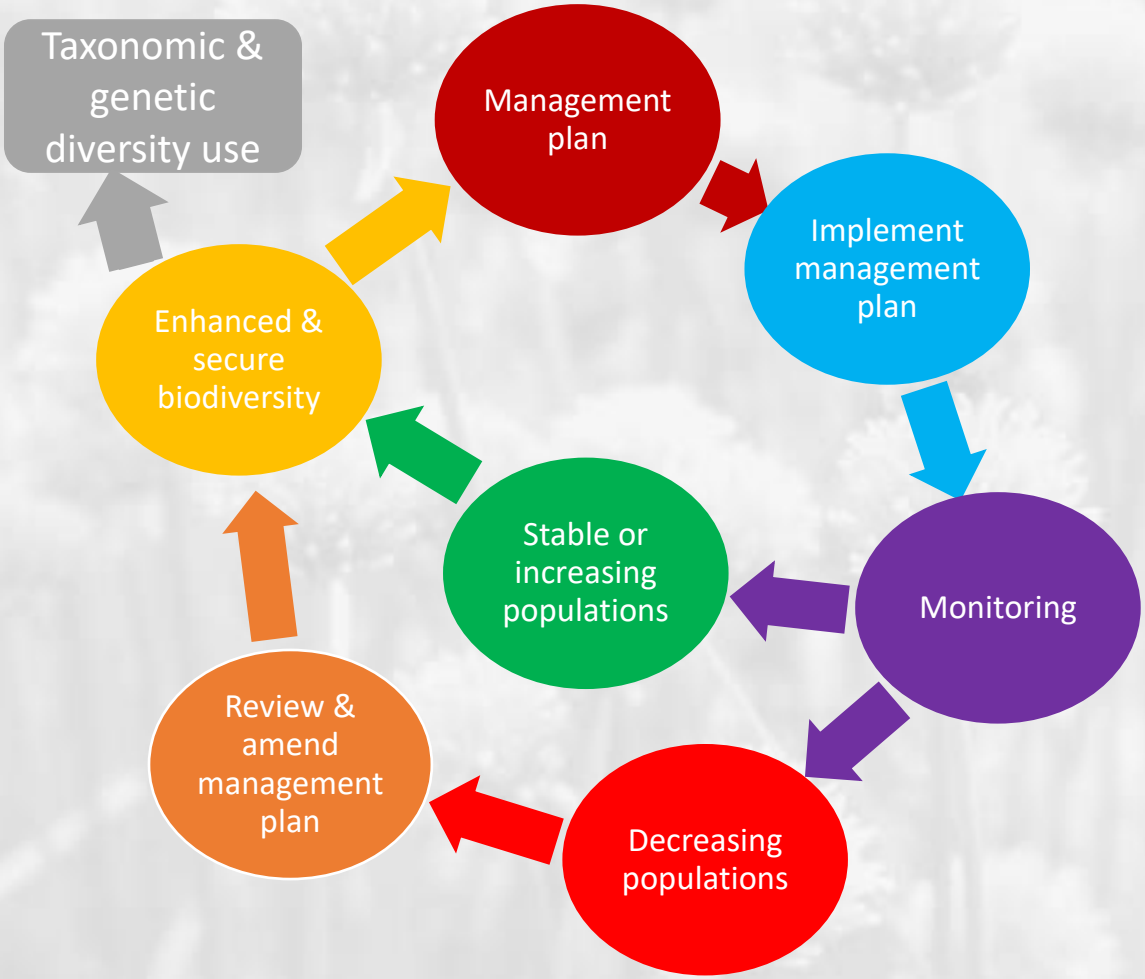
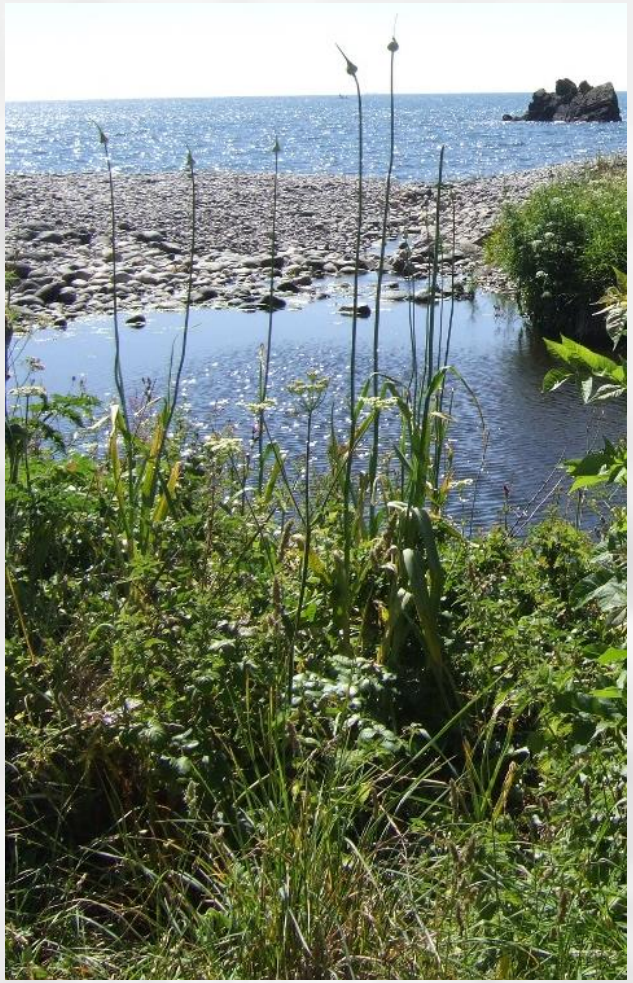
Step 2 – *In Situ* Conservation implementation



Genetic reserve management cycle



Lizard NNR, Cornwall, UK, first UK CWR genetic reserve

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Partnerships

CWR, WHS or LR *in situ* population conservation	
National GRC staff's role	**PGR population maintainer's role**
International, national and local policy development.	Preparation, implementation and periodic revision of site management plan.
National conservation planning.	Management of target populations.
Target population national network management.	Monitoring of target populations.
Target population characterization and evaluation.	Periodic collection of target populations to make representative *ex situ* backup samples, for backup, c & e and user access.
Ensuring user access to *in situ* conserved resources (via the *ex situ* backup sample).	Promotion of PGR integration into the broader biodiversity community.
Lead and participate in *PGR* In Situ *Population Management Committee*.	Participation in *PGR* In Situ *Management Committee*.

Maxted *et al.* (2024)

Paul Watkins with his Squareheads Master wheat

Suffolk, UK – house thatched with Squareheads Master wheat

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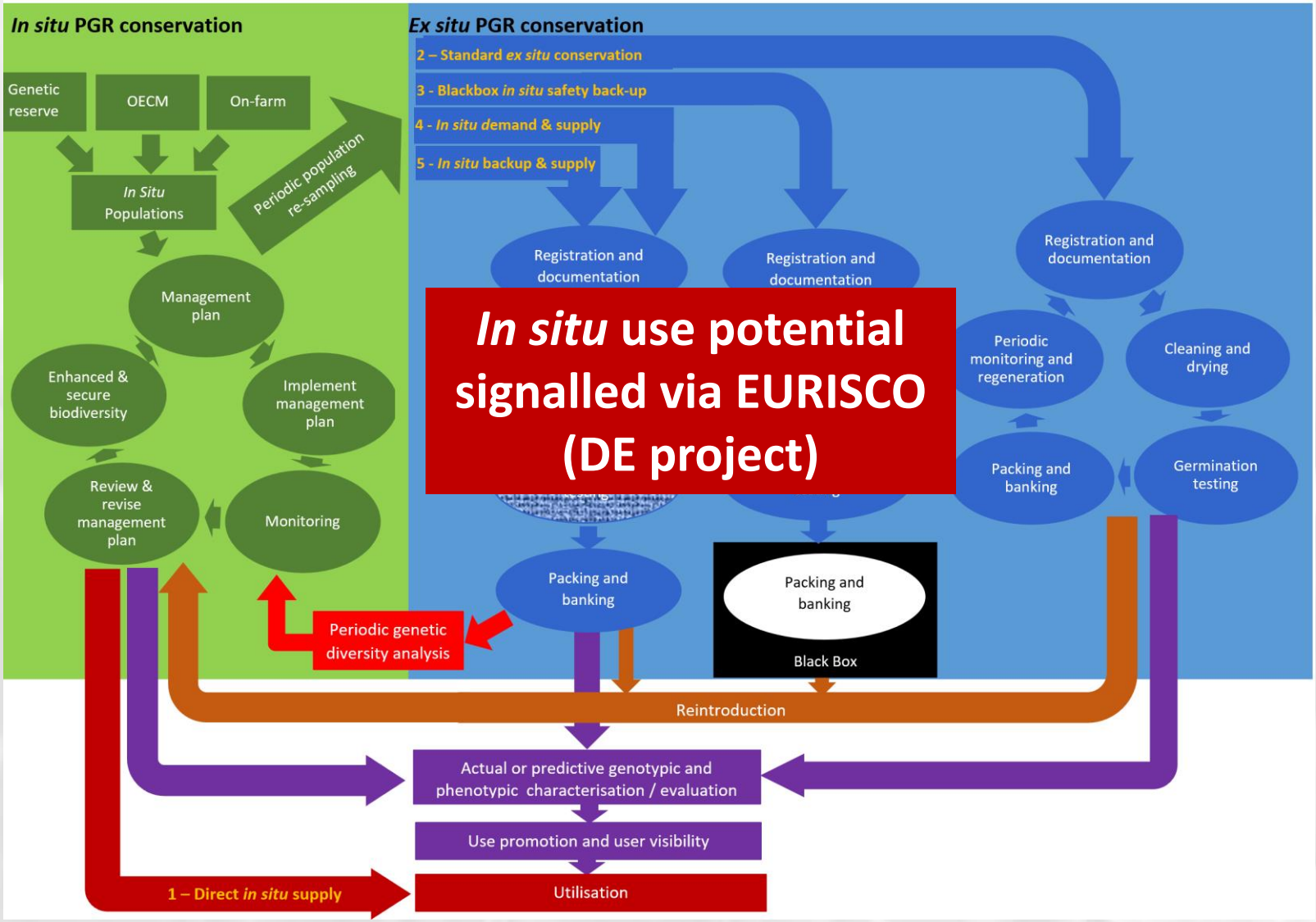
Step 3 – *In situ* → *ex situ* → use linkage



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Step 4 – Diversity utilisation

ICARDA Pre-breeding Programme:

- Identify desired adaptive trait(s)
- Predictive characterisation of LR and CWR
- Identify potential germplasm donors, either conserved or unconserved
- Confirm predicted adaptive trait presence using genomic analysis
- Crossing of existing varieties with target germplasm containing desired trait(s)
- Generate advanced material with desired trait(s)
- Use prebred advanced material in ICARDA programmes or distribute to national programmes in CWANA region

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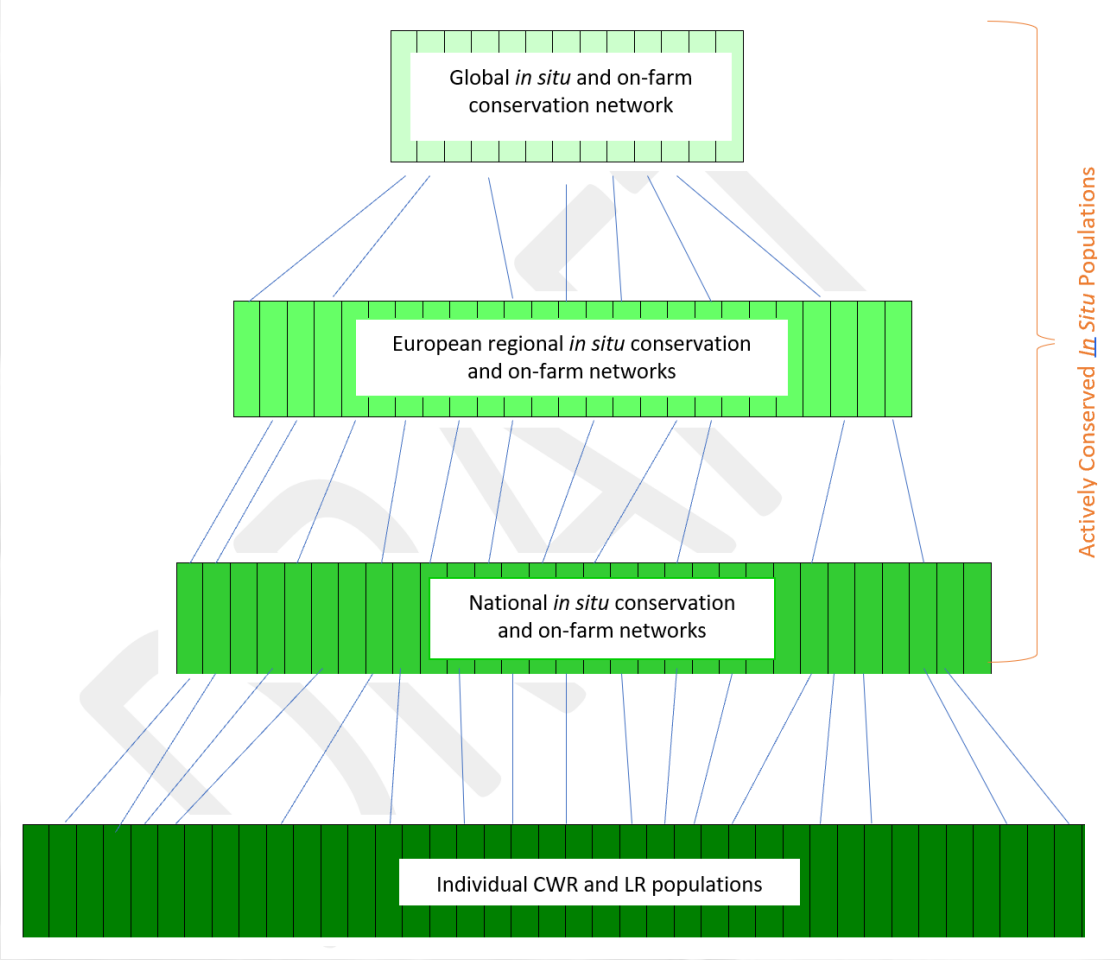
Networking

Network is preferable – why?

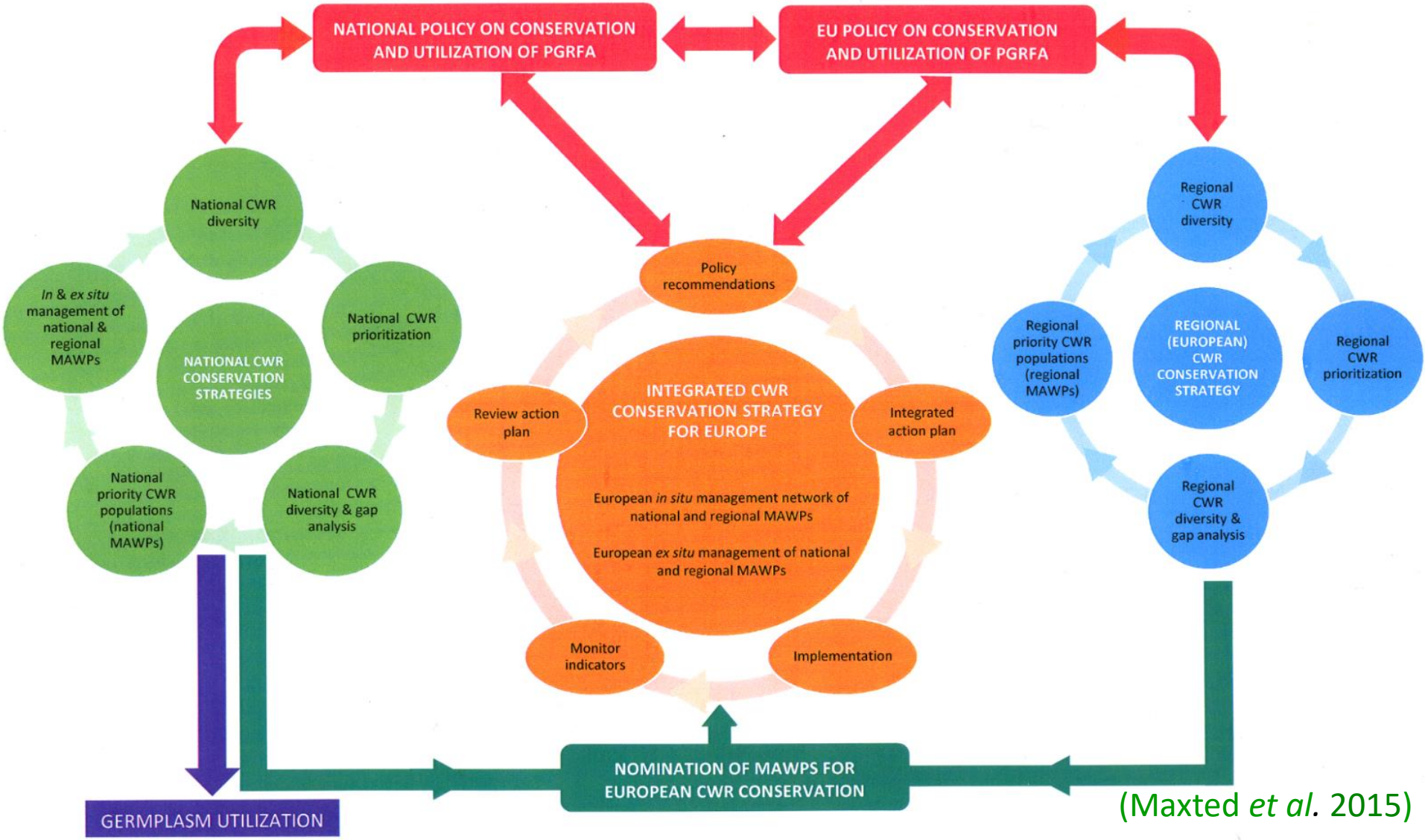
- Facilitate systematic coordination and reporting (e.g. GPA)
- Foster stronger partnerships and mutual support
- Integrate global, regional and national actions
- Link local communities of practice with common goals
- Facilitate ABS for protected areas and farmers / farming communities
- Enable integrated, long-term complementary *in situ–ex situ* conservation
- Promote access to PGR held in protected areas and farmers / farming communities via Genetic Resource Centres
- Safeguard evolving *in situ* PGR populations for perpetuity

GRACE RI: Pillar 2 *In situ* conservation Networking

Linking global, European and national *in situ* conservation actions



GRACE RI: Pillar 2 *In situ* conservation
Networking



(Maxted *et al.* 2015)

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Network Partnership

Why sites should join network

- ✓ Kudos and prestige of belonging to an international community of appreciation, legislative protection of site and concern for the value of PGR diversity
- ✓ Make a contribution to something bigger / stronger partnerships
- ✓ Assistance in adding value to your work, developing markets and fostering greater cross-sector collaboration, and sustainable use activities – such as increased opportunities for improved marketing through a certification schemes
- ✓ Offer technical support and training for *in situ* plant genetic resources conservation and sustainable use activities, as well as guidance in seeking funds and agri-environmental schemes to support specific initiatives, such as management interventions and research
- ✓ Provide a platform for access to reliable expertise, information, knowledge sharing and collaboration and *in situ* management tools, protocols, exemplars, evidence-base, etc.

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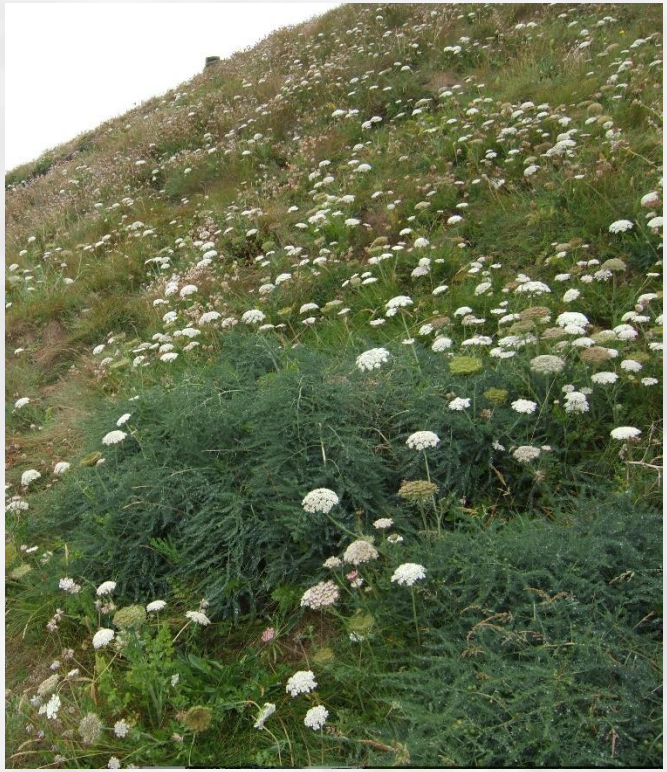
Network Partnership

Mutually beneficial collaboration between PA and PGRFA communities:

- Agrobiodiversity community
  - Problem: Need for greater diversity and lack of systematic CWR conservation is threatening food security, requires *in situ* action, but can't do it alone
  - Benefit: systematic CWR conservation and significantly more CWR diversity available for use
- Protected area community
  - Problem: Difficult to show link to UN Sustainable Development Goals and insecurity of funding
  - Benefit: Clear link to additional ecosystem services value at minimal additional cost, raising public awareness of applied nature of conservation



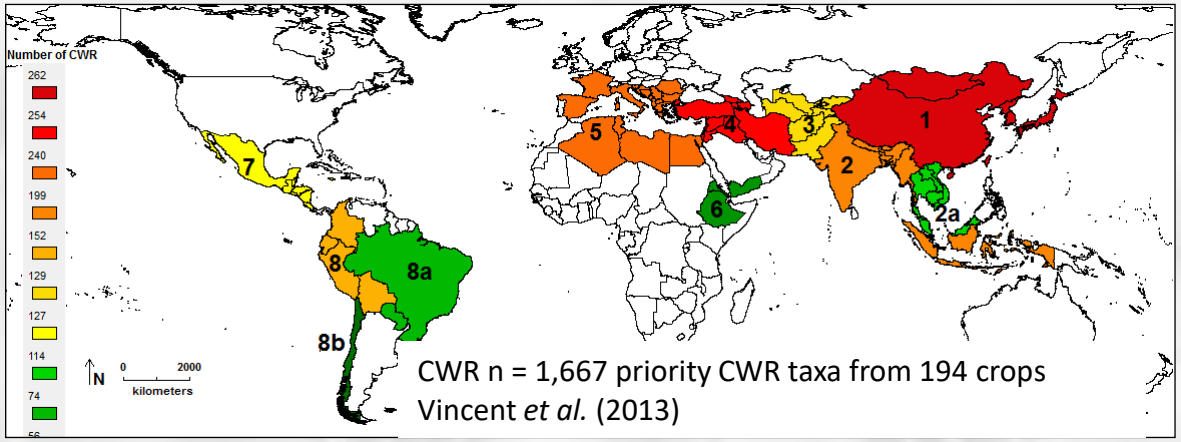
Asparagus officinalis subsp. *prostratus*

GRACE RI: Pillar 2 *In situ* conservation

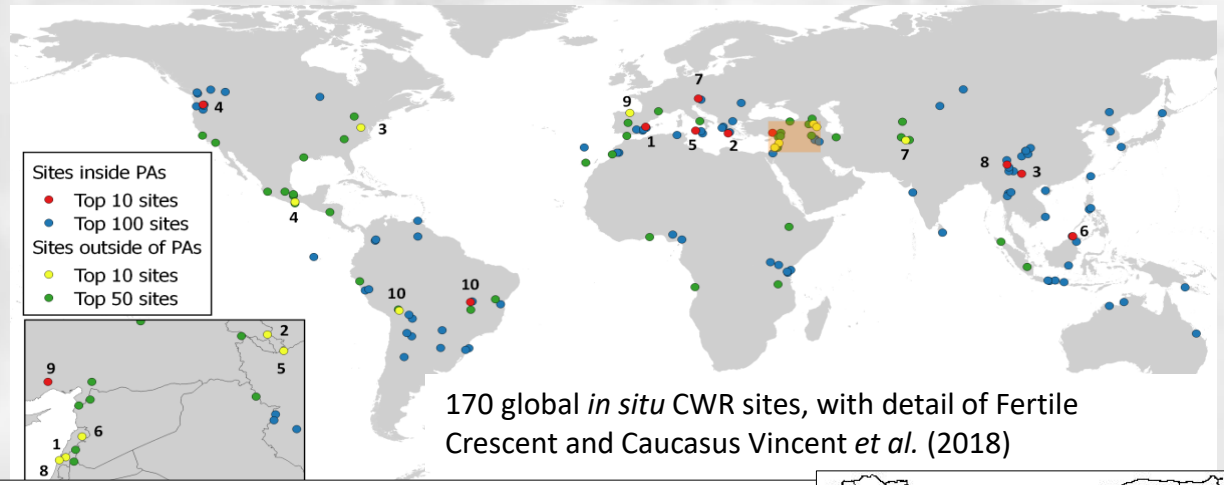
Potential to double genetic diversity available to users

- Currently:
  - Crop breeders calling for access to greater diversity to address climate change (Volbrecht and Sigmon, 2005; Feuillet *et al.,* 2008; Dwivedi *et al.*, 2008; McCouch et al., 2013)
  - CWR are suffering erosion and extinction – 16 to 35% are IUCN threatened (Bilz *et al.*, 2011; Kell *et al.*, 2012; Goettsch *et al.*, 2021)
  - 99% of CWR conservation is *ex situ* as seed in genebanks and supplies users (Maxted *et al.*, 2016)
  - Analysis of CWR holdings shows ≈ ⅓ unconserved, ≈ ⅓ poorly conserved (<10 accessions) and 95% are under-collected (Castañeda *et al.* (2016)
- Complementary conservation means applying *ex situ* and *in situ* techniques together, but *in situ* (incl. on-farm) conservation is almost completely ignored – a handful of active PA and OECM (Other Effective Area-based Conservation measures) for CWR and few long-term on-farm conservation sites
- Systematically applying CWR *in situ* conservation could at least double the diversity available to users who are acknowledging PGR availability is limiting breeding options

The Turkish CWR Exemplar

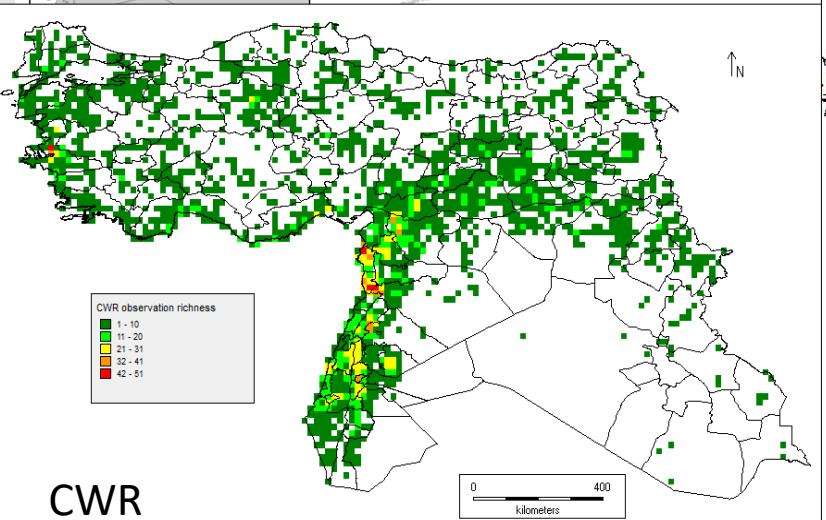


CWR n = 1,667 priority CWR taxa from 194 crops Vincent *et al.* (2013)

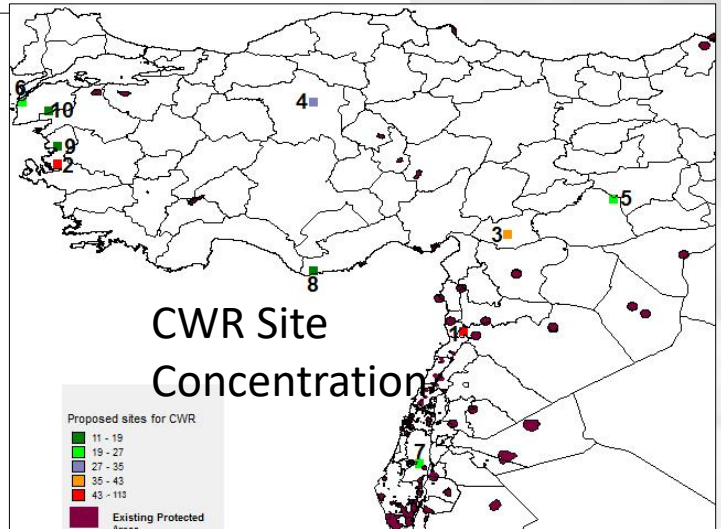


170 global *in situ* CWR sites, with detail of Fertile Crescent and Caucasus Vincent *et al.* (2018)

Forage legume collection among LR led by AARI Turkey (1987, 1988)



CWR

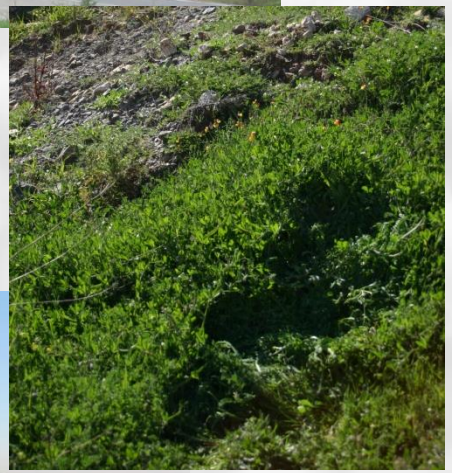


CWR Site Concentration

8 out of 10 hotspots in the Fertile Crescent are in Turkey

The Turkish CWR Exemplar

- In 1987 near Cavus, Antalya province, Turkey while collecting food, fodder and forage legume species with AARI we found a new species that we named *Lathyrus belinensis*.
- Single population growing alongside new road between Kumluca and Tekirova, especially around an ungrazed village graveyard in Belin, we and other have searched elsewhere but it has not been found away from this location
- Species was a member of *Lathyrus* section *Lathyrus* and most closely related to *L. odoratus* (sweet pea), being just as scented as sweet pea but with yellow flower, so was an opportunity for horticulturalists to breed a yellow sweet pea = potential economic value of 10-15M dollars
- Attending a conference in 2010 in Antalya I decided to drive across to see the species—the original type location had been completely destroyed by earthworks associated with the building of a new police station
- Although a few plants were found in the area and seed is held AARI and ICARDA genebanks *ex situ*, the richest area within the site had been lost
- To draw attention to the species I applied the IUCN Red List Criteria and found to be Critically Endangered—the most highly threatened category
- The species has significant economic potential but is very near extinct in the wild. I also revisited the site in 2015 when the coastal road was being expanded to a coastal highway and found only five plants in the graveyard



Moving towards Pillar 2 Implementation

Commitments to *in situ* networking