UNIVERSITY OF BIRMINGHAM

ECP/GR ERFP EUFORGEN

GenRes Bridge

Farmer's Pride

Towards effective networking for European (and global) in situ plant agrobiodiversity conservation

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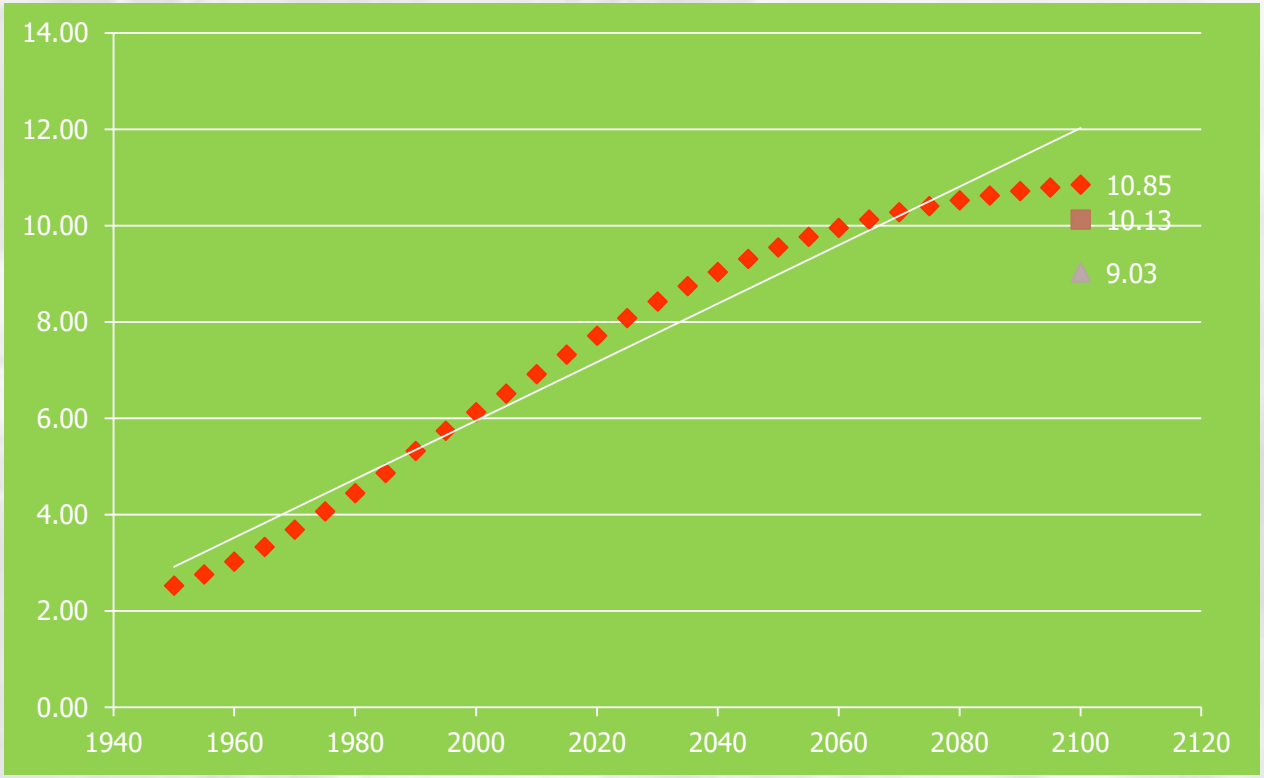
Talk overview

- The problem of plant agrobiodiversity conservation is:
  - CWR / LR are threatened and poorly conserved and lack of diversity is now inhibiting crop improvement
  - No holistic ABD conservation integration at global, regional, national and local geographic scales
  - Uncomplementary conservation
  - Application of new techniques offer more comprehensive conservation e.g. at the global level is highlighting ABD hotspots
- Establishment of an *in situ ABD* networks for Europe
  - Function
  - Structure
  - Governance
  - Integration of *in situ* with *ex situ*
  - Transforming gene banks into genetic Resource centres

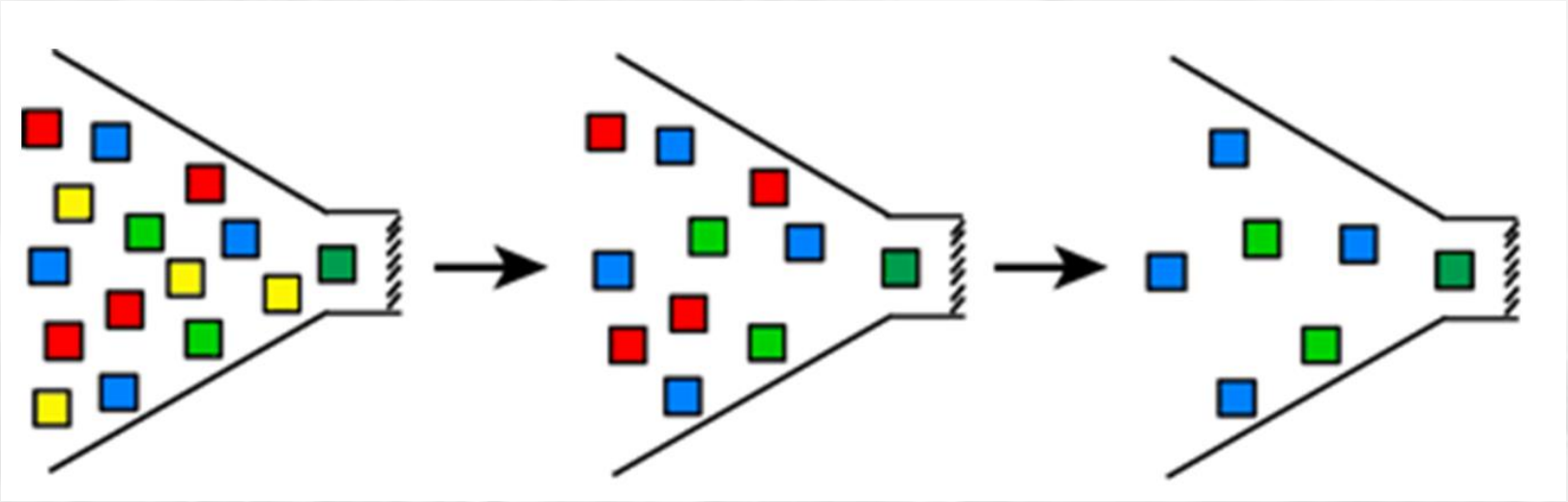
Humans beyond the planets carrying capacity?

- 7.22 billion in 2019, 78% live in developing countries (UN, 2019)
- 9.6 billion by 2050, 86% in developing countries (primarily Africa)



- To feed humans in 2050 require food supplies to increase by 60% globally (FAO, 2011)
- Climate change may reduce agricultural production by 2% each decade by 2050 (IPCC, 2014)

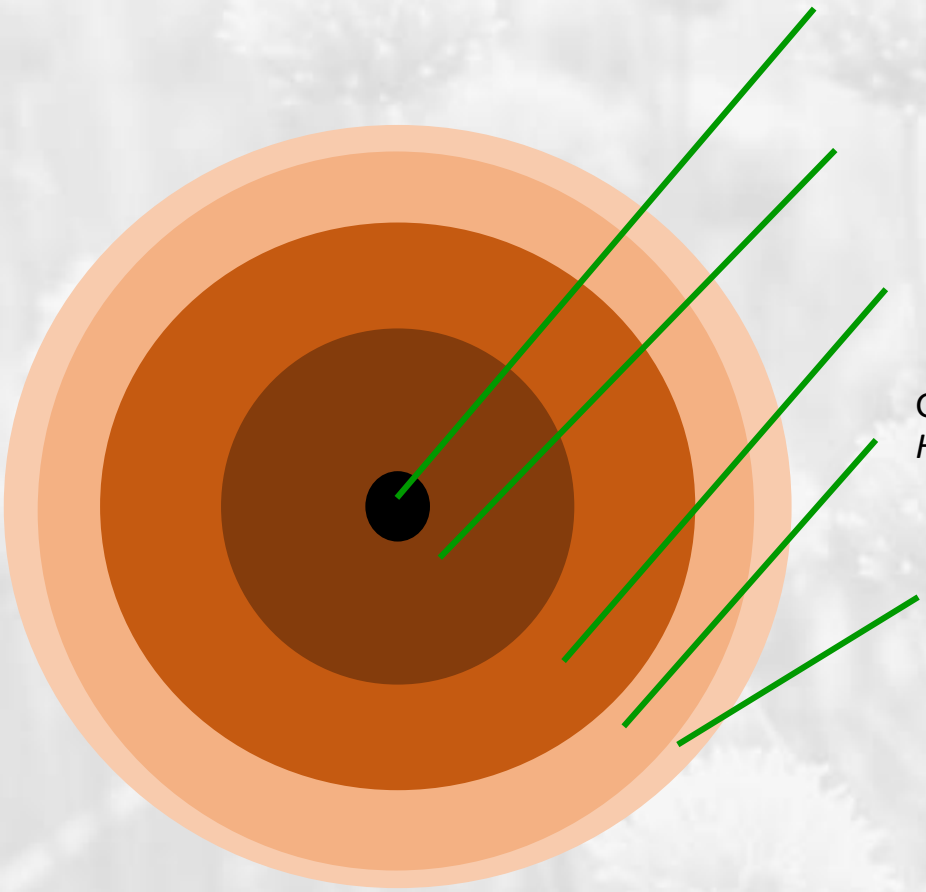
Where is adaptive diversity?



Wild species Landraces Modern varieties

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

Where is adaptive diversity?



GP1a Breeders' lines & varieties e.g. Maris otter

GP1a Landraces (LR) e.g. Bere on Hebrides Isles, Scotland.

GP1b Primary CWR e.g. *Hordeum vulgare* subsp. *spontaneum*

GP2 Secondary CWR e.g. *Hordeum bulbosum*

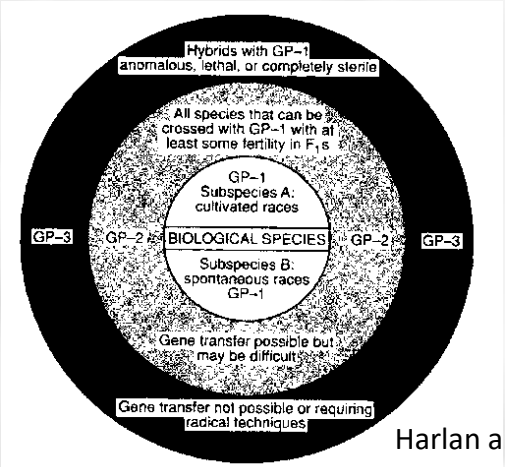
GP3 Other *Hordeum* spp.

Hordeum vulgare ssp. *spontaneum*

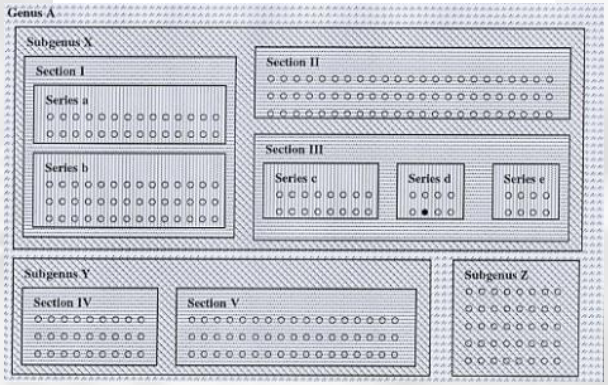
Relative genetic diversity held at each level of the barley genepool

What are crop wild relatives?

- Crop wild relatives (CWR) are wild plant species closely related to crops, including wild ancestors
- They have an indirect use as gene donors for crop improvement due to their relatively close genetic relationship to crops
- They are an important socio-economic resource that offer novel genetic diversity required to maintain future food security



Harlan and de Wet (1971)



Maxted et al. (2006)

Broad definition:

CWR = all taxa within the same genus as a crop

Maxted *et al.* (2006)

More precise definition:

A crop wild relative is a wild plant taxon that has an indirect use derived from its relatively close genetic relationship to a crop; this relationship is defined in terms of the CWR belonging to gene pools 1 or 2, or taxon groups 1 to 4 of the crop

What are crop landraces?

- Harlan (1975) defined a landrace as "populations that have evolved in subsistence agricultural societies as a result of millennia long, artificial human selection pressures, mediated through human migration, seed exchange as well as natural selection"
- Hawkes (1983) extended the term by adding the association with marginal environments, lack of direct competition with highly bred cultivars
- Bellon and Brush (1994) consider that a landrace is constituted by traditional farmers' varieties.
- Zeven (1998) in a review of landrace definitions concluded that as a landrace has a complex and indefinable nature, an all-embracing definition cannot be given

Camacho Villa *et al.* (2005) six characteristics:

"A landrace is a dynamic population of a cultivated plant species that has

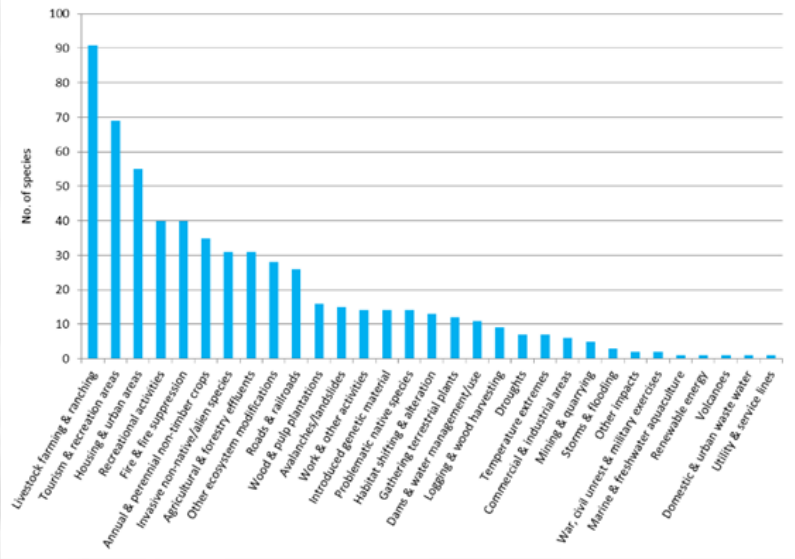
1. *historical origin,*
2. *distinct identity and*
3. *lacks formal crop improvement,*
   as well as often being
4. *genetically diverse,*
5. *locally adapted and associated with*
6. *traditional farming systems"*

7. \+ often has cultural associations

Why crop wild relatives?

CWR are threatened and poorly conserved

- Red List assessments of 572 native European CWR in 25 Annex I priority crop gene pools
  - 16% of the species assessed are threatened or Near Threatened and 4% are Critically Endangered
- Yet analysis of European PGR *ex situ* collections found:
  - CWR taxa represent only **10%** of total germplasm accessions and only **6%** European CWR have any germplasm in gene banks (Dais 2010)
  - 72% of CWR globally are under-conserved in gene banks (Castañeda-Álvarez et al., 2016)
- Many CWR are found in existing protected areas, but they are not being actively monitored and managed
- Only a handful of CWR active genetic reserves have been established: *Triticum* CWR in Israel; *Zea perennis* in Mexico; *Solanum* CWR in Peru; wild Coffee CWR in Ethiopia; and *Beta patula* in Madeira (Maxted et al. 2016)



Kell et al. (2012) Red listed 571 European CWR species

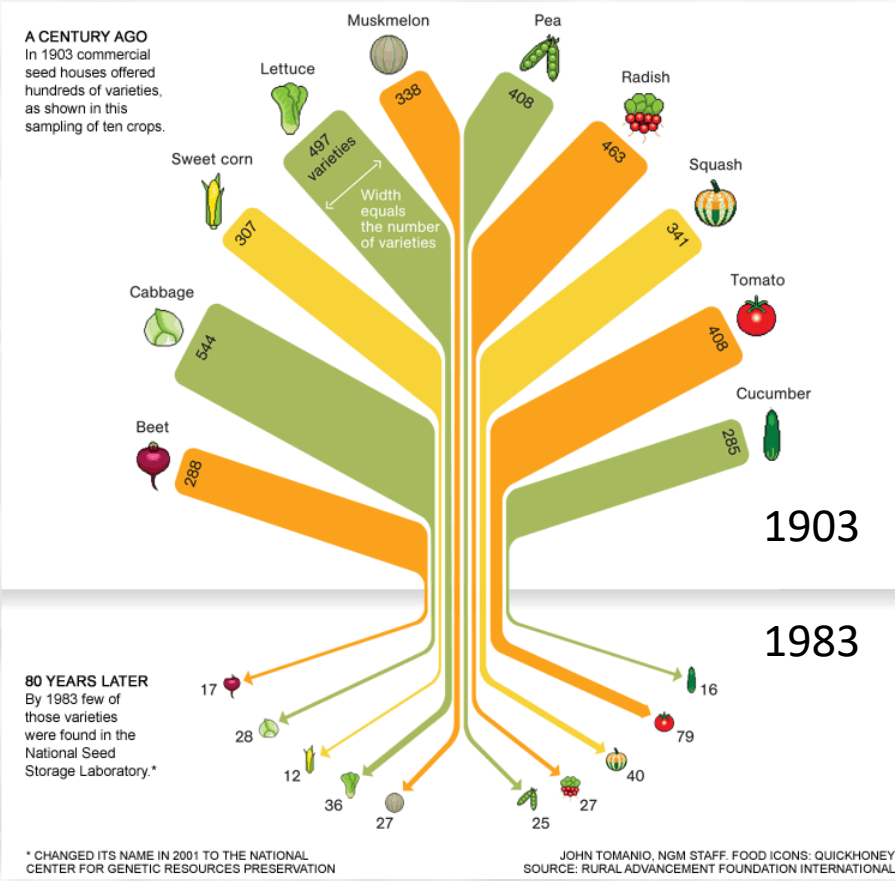
Why crop landraces?

LR are threatened and poorly conserved

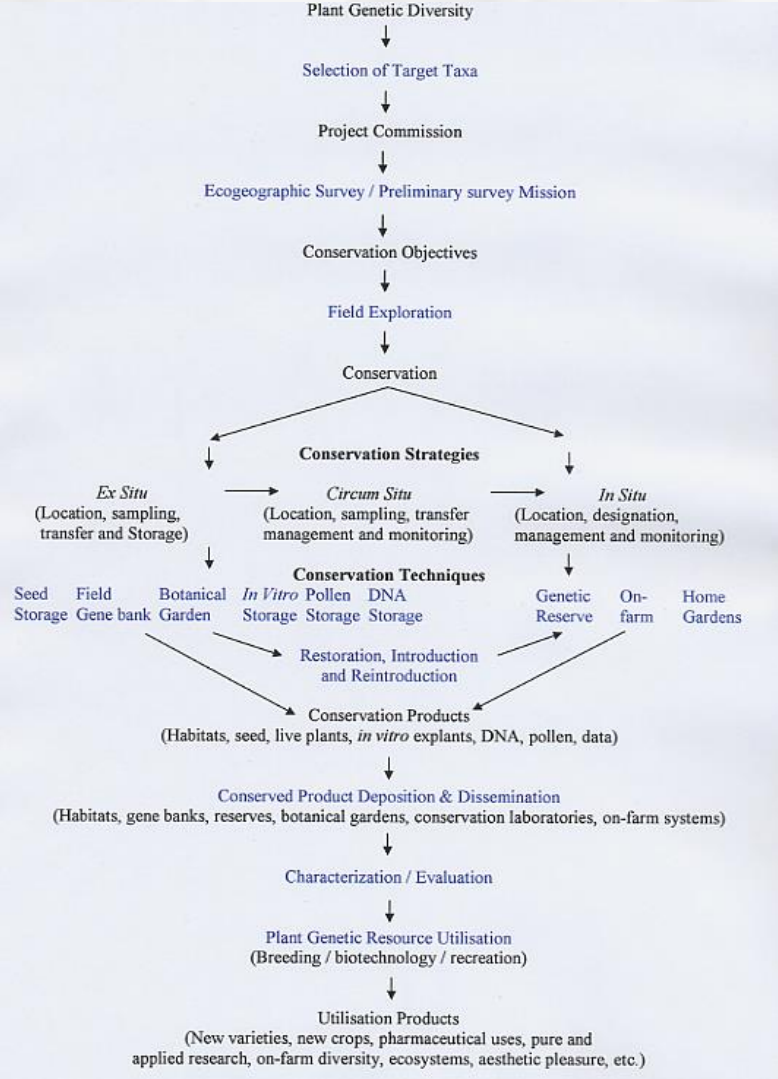
- **Most severely threat element of biodiversity are LANDRACES (Maxted, 2008)!**

- Why?
  - We have no idea how many LR exist
  - Landrace maintainers are almost always older and their number is dwindling each year (= average age in Scottish islands is 65 in 2003)
  - Farmers are by definition commercial they grow what yields the highest economic return, they are not conservationists
  - Seed companies, breeders and government agencies are actively promoting modern cultivar replacement of LR
  - In most countries no agency has direct responsibility for their conservation
  - No country has a comprehensive inventory of extant LR

- Unless action is taken immediately LR loss will continue and complete extinction is the only possible conclusion



Holistic Integration of PGRFA Conservation



Utilitarianism + Geography

- Conservation linked to
  - Use
- National
- Regional
- Global

Complementary Conservation

- AIM: “combining *in situ* and *ex situ* techniques to maximize within-species diversity conservation and availability for the user”

- If the two approaches are combined
  - *Ex situ* conservation can provide
    - Facilitated use of *in situ* and *ex situ* conserved populations
    - Safety back-up of *in situ* conservation
    - Conservation of CWR species/populations for which *in situ* conservation is not the best approach (e.g. Syria CWR hotspot but currently)
  - *In situ* conservation can provide
    - Conservation of whole populations
    - Broad spectrum conservation (whole ecosystem, many species)
    - Conservation of adaptive processes in the natural environment (potential adaptation to changes in the climate, disease pressures etc.)

- Currently 99% funding is focused on *ex situ* conservation

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."

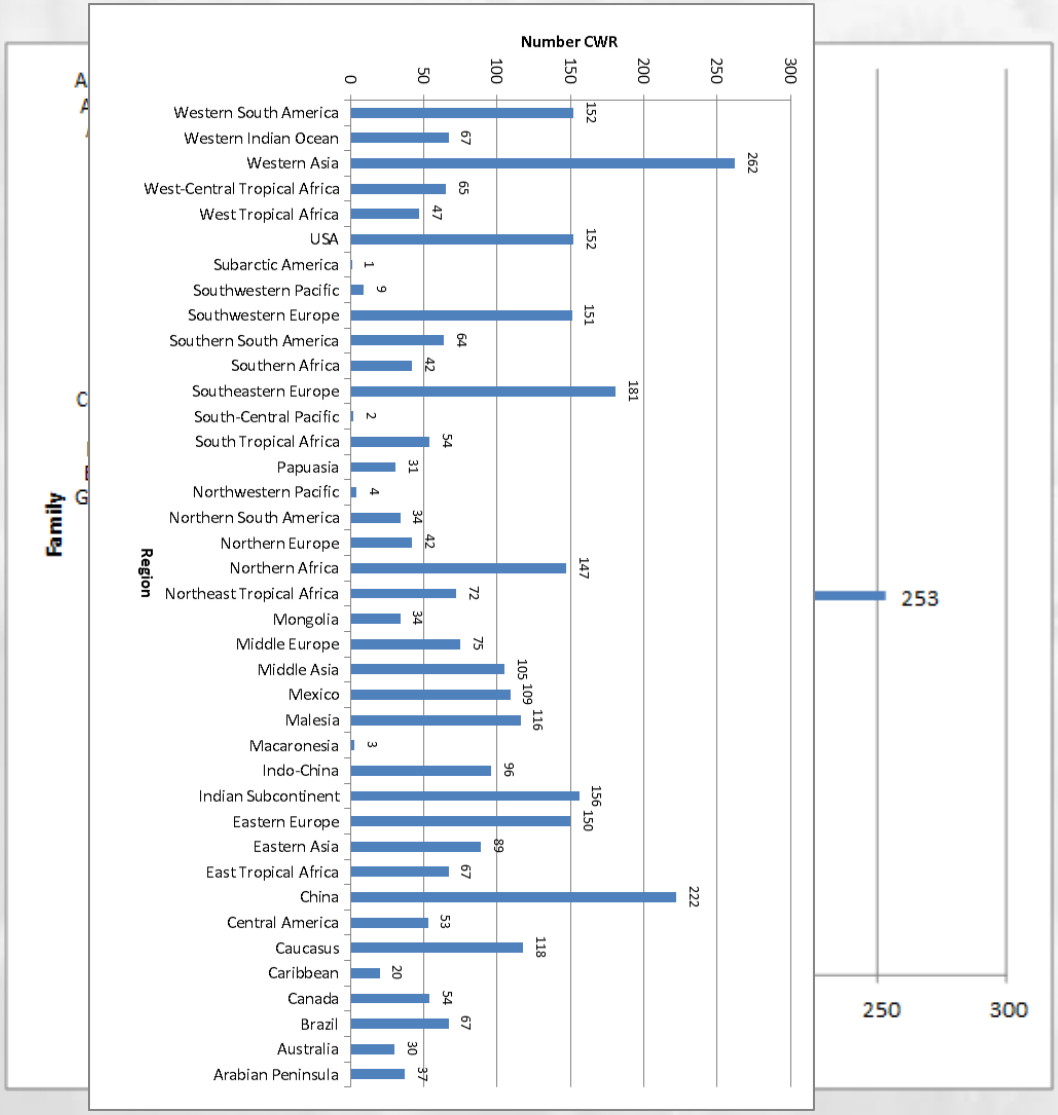
- UN Sustainable Development Goals highlighted the need of eradicating extreme poverty and hunger = Goal 1, 2 and 3, but particularly 2.5

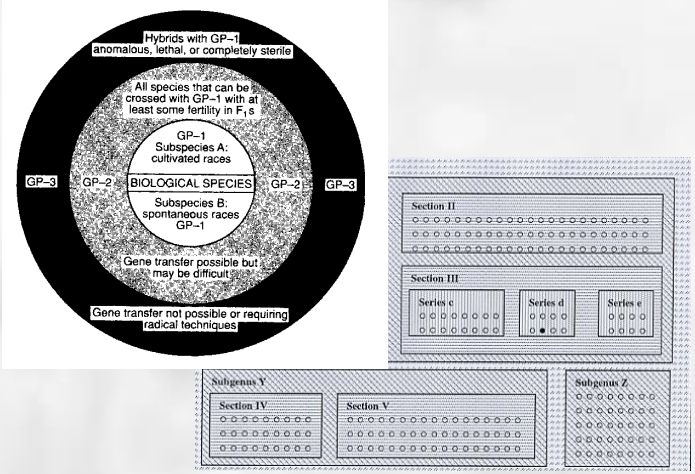
Vavilovia formosa:
CWR of garden pea

Crop Trust CWR Project

- Global Crop Diversity Trust project with Norwegian Gov. funding
- Primarily use orientated, but *ex situ* collecting in first 5 years:
    1. List of gene pools and taxa to collect 92 genera with crops
    2. Ecogeographic data collection
    3. Gap analysis using Maxted *et al.* (2008) / Ramírez-Villegas *et al.* (2010) methodology
    4. Field collection
    5. *Ex situ* storage

Global Crop Diversity Trust: global *ex situ* CWR conservation





Harlan and de Wet Inventory

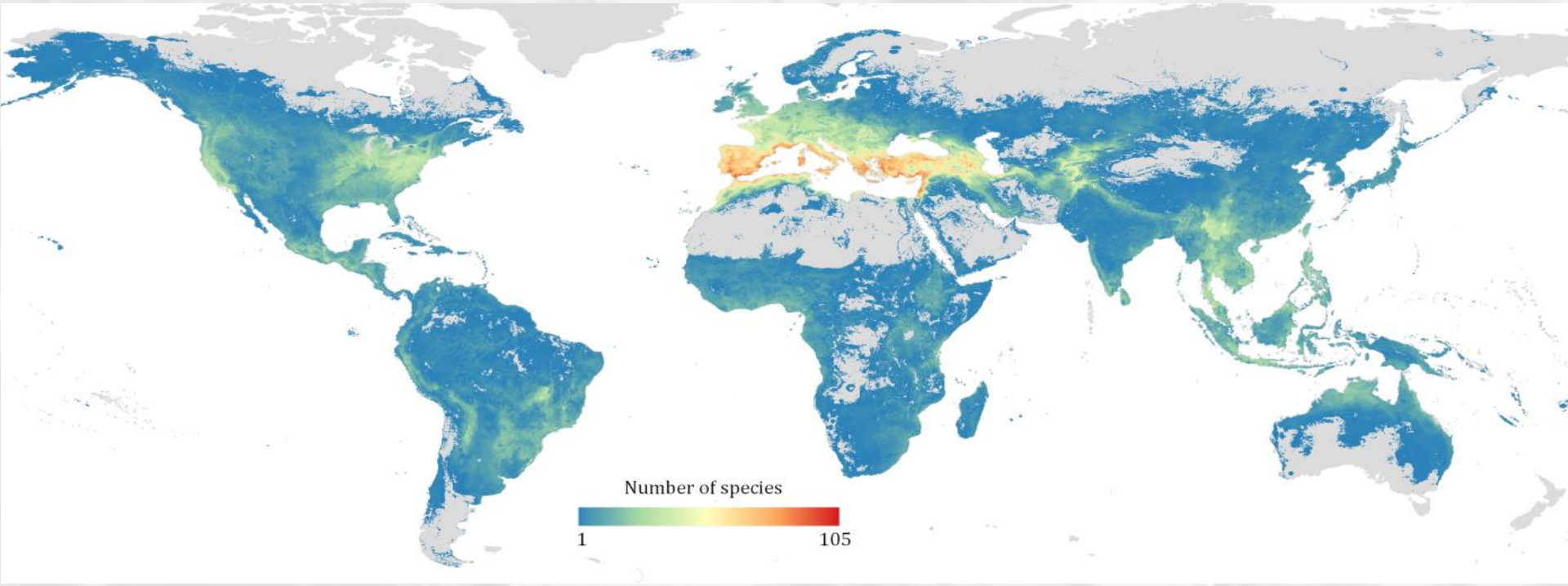
1,667 priority CWR taxa from 194 crops

- 37 families
- 109 genera
- 1,392 species
- 299 sub-specific taxa

Vincent *et al.* (2013)

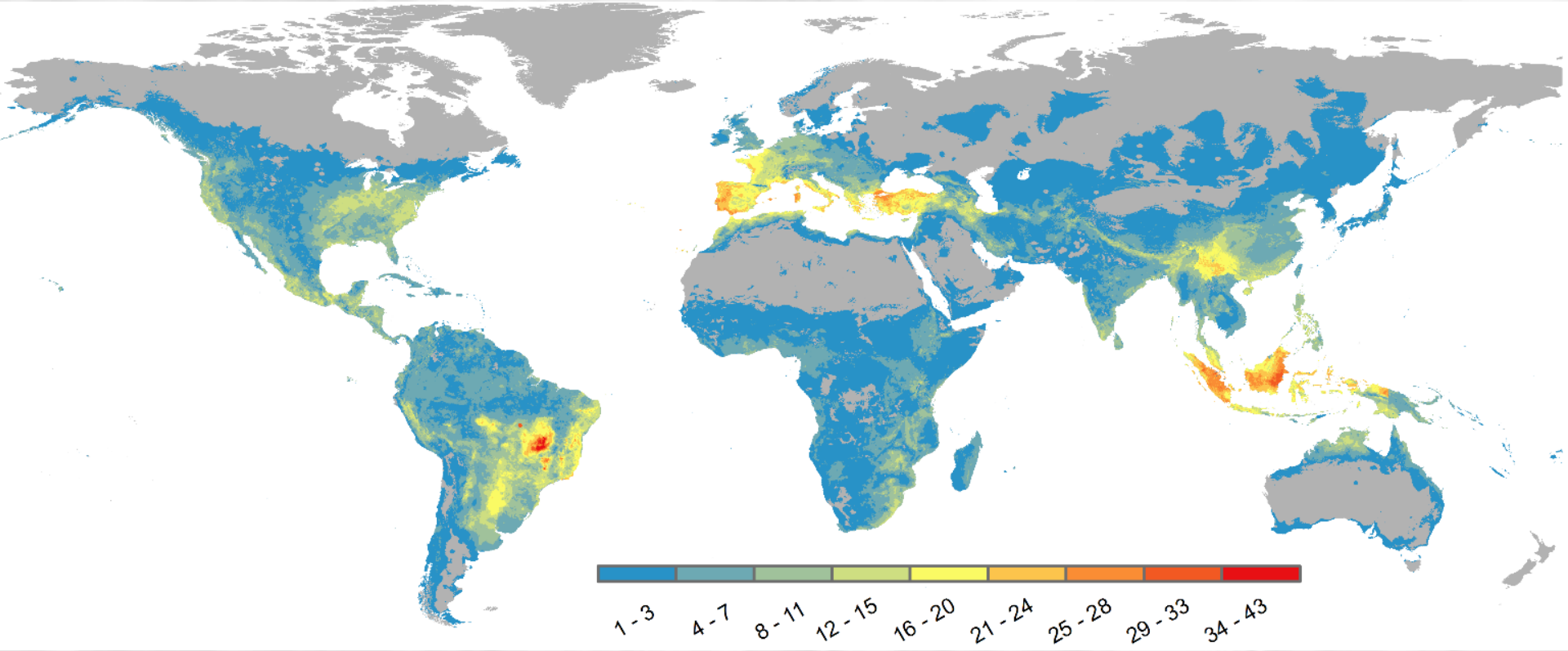
http://www.cwrdiversity.org/checklist/

Global CWR Conservation



Species richness map for the priority 1,394 CWR related to 194 crops at five arc minutes resolution (Vincent *et al.,* 2019).

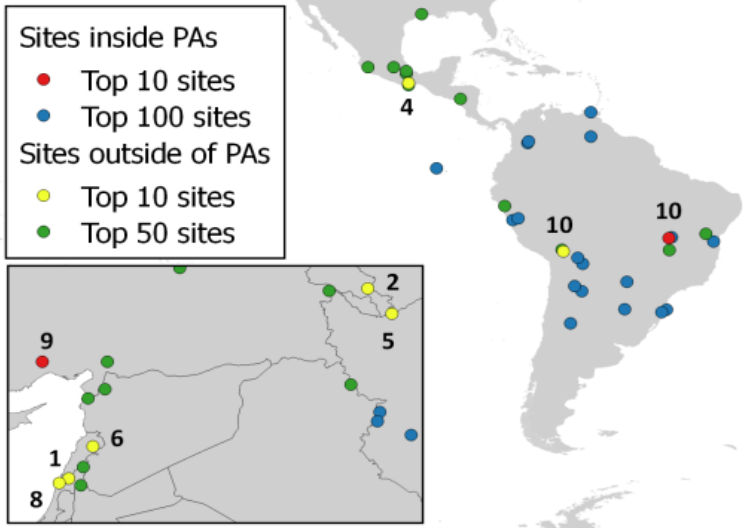
Global CWR Conservation



Global collecting hotspots for High Priority CWR for 1,026 CWR related to 81 crop gene pools (Castañeda-Álvarez *et al.*, 2016).

Global CWR Conservation

A PROPOSAL:
NI Vavilov Global Network for CWR Conservation



- Each species has a minimum of 5 sites
- Sites are selected to maximise genetic diversity conservation using ELC maps
- All sites are tested for relative climate change impact

Top 170 sites for global *in situ* CWR conservation (100xPA and 50xnon-PA), with magnification on the Fertile Crescent and Caucasus (Vincent *et al.,* 2019).

European GR Conservation

Farmer's Pride (H2020 funded) has 44 partners from diverse communities – farmer, agrobiodiversity, conservation and civil society NGOs; plant breeding/seed sector; public research institutes; and protected area networks (incl. Eurosite) – D4.4 European *in situ* conservation network of sites/stakeholders

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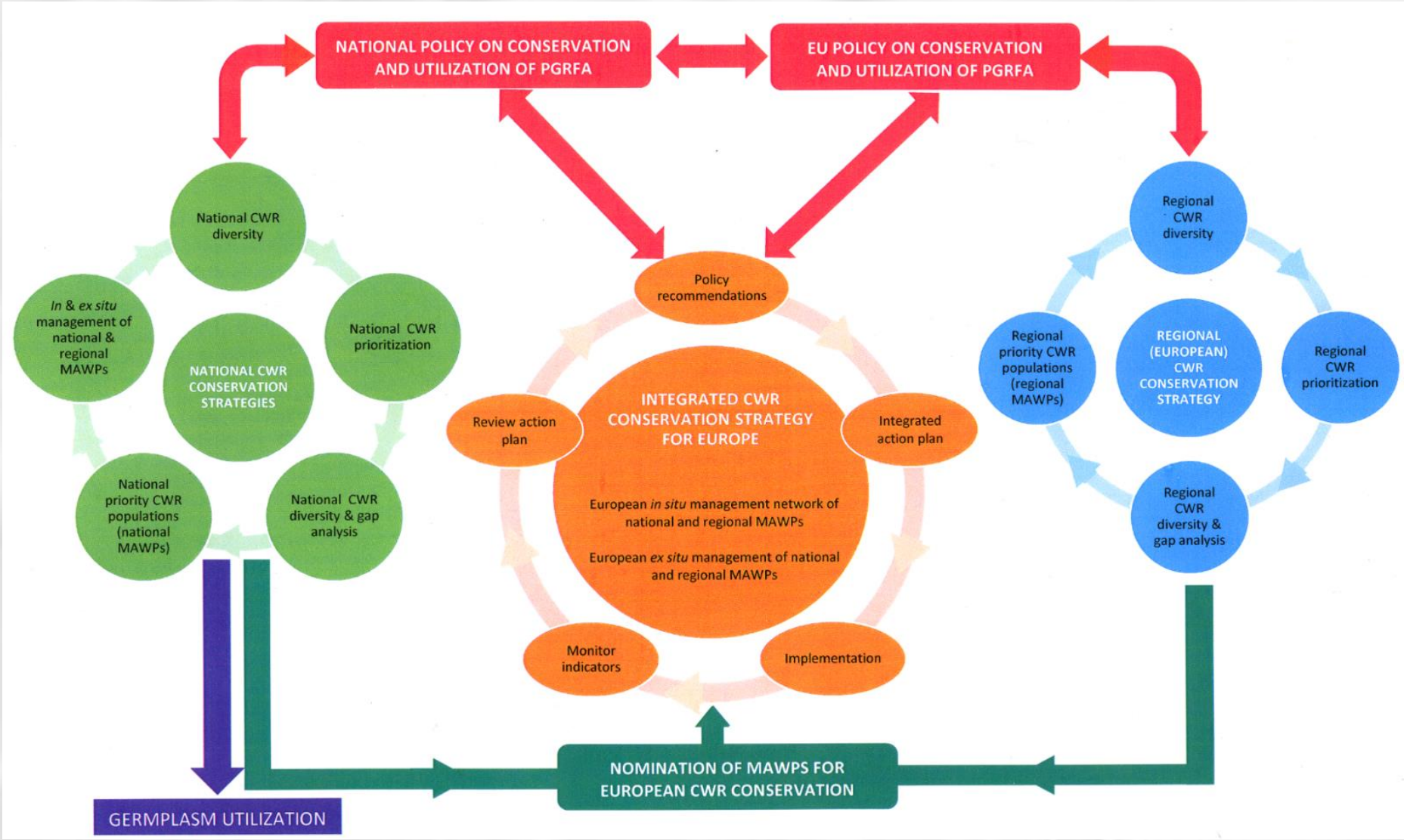
In situ networks of CWR populations
Function

- Facilitating coordination;
- Fostering stronger partnerships (funding) at national, regional and global levels;
- Impacting positively on activities at country-level;
- Working with local communities;
- Active *in situ* conservation and safeguarding in perpetuity of important genetic resources;
- Better linkages between conservation and sustainable use.
- Significantly enhances diversity to users

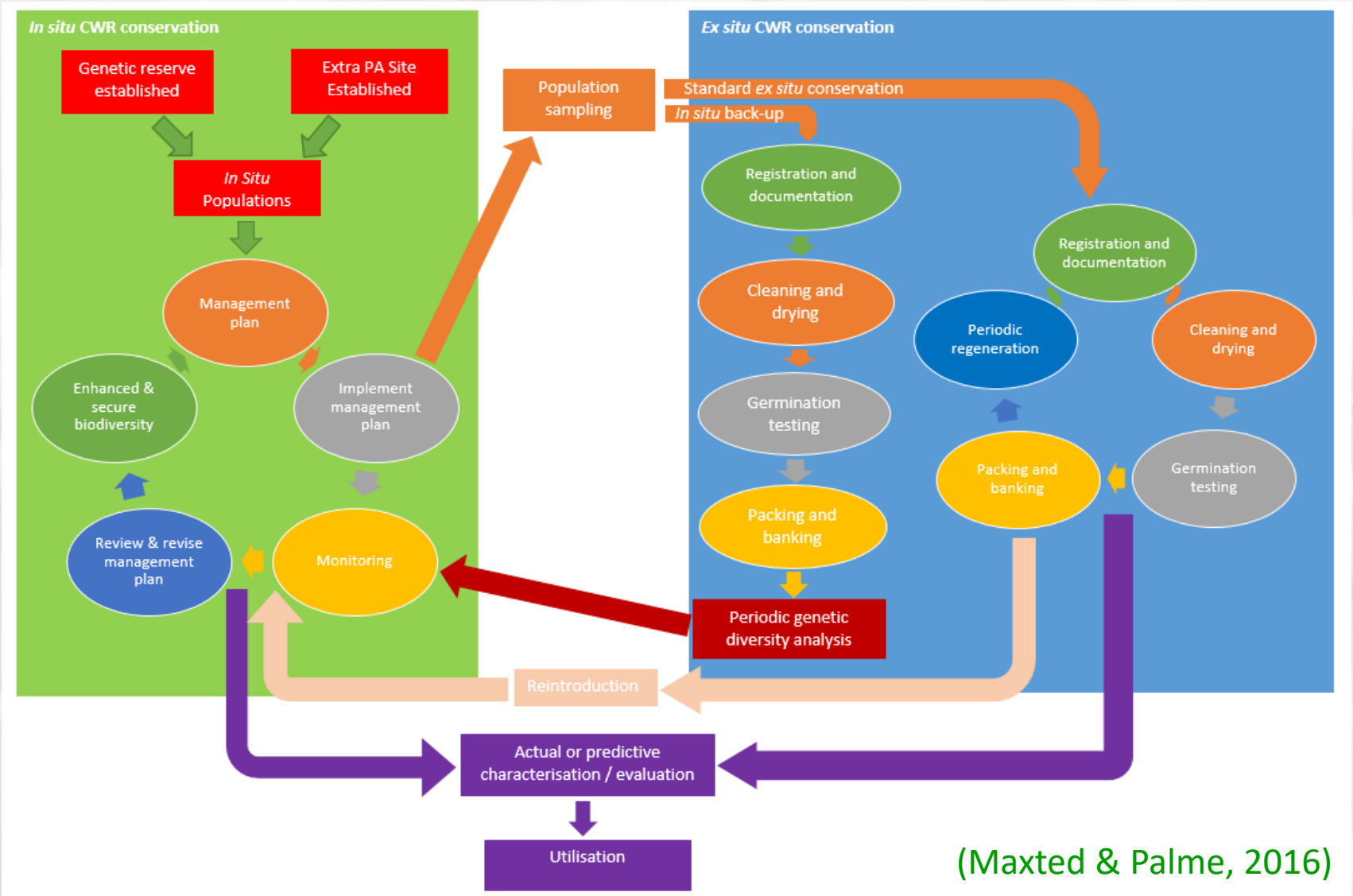
In situ networks of CWR populations

Structure



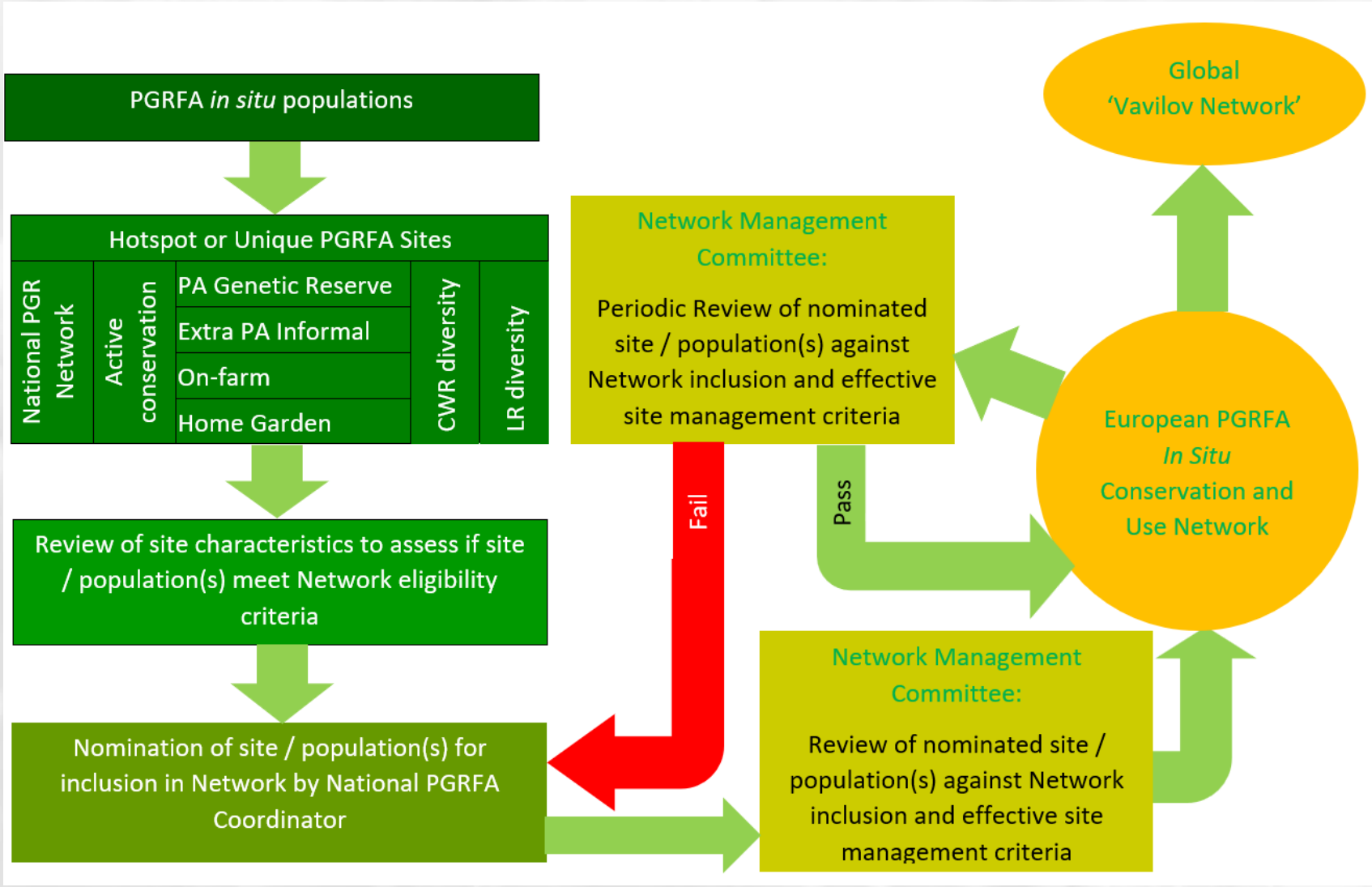
(Maxted *et al.* 2016)

In situ networks of CWR populations
Integration of *in situ* and *ex situ*



(Maxted & Palme, 2016)

In situ networks of CWR populations
Governance: a work in progress ….



Take Home Message

- CWR have significant value for food security, but CWR also are under-conserved and threatened, CWR value is recognized and policy context has been established, action will achieve societal benefit
  - Pimentel et al. (1997) CWR worth $115 billion toward increased crop yields per year
  - PWC (2013) CWR related to 29 major crops are worth $115 billion toward increased crop yields per year
  - Analysis top 300 crops shows CWR used in breeding of 5% = potential value of $2.3 trillion annually?
- GSPC Target 9 is NOT EVEN NEARLY ACHIEVED
  - *Ex situ* conservation 28% (Based on Castañeda-Álvarez *et al.,* 2016)
  - *In situ* conservation 0-2% (Based on Maxted *et al.,* 2017)
- Lack of adequately conserved and available CWR diversity is limiting crop improvement and food security –
  - 70% of gene pool genetic diversity is found in CWR taxa
  - *In situ* and *ex situ* genetic conservation
  - In situ conservation use is the weak point, therefore gene banks to PGRC