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# Addressing GSPC Target 9: Toward the systematic conservation of global plant agrobiodiversity to 2020 and beyond – Report Card

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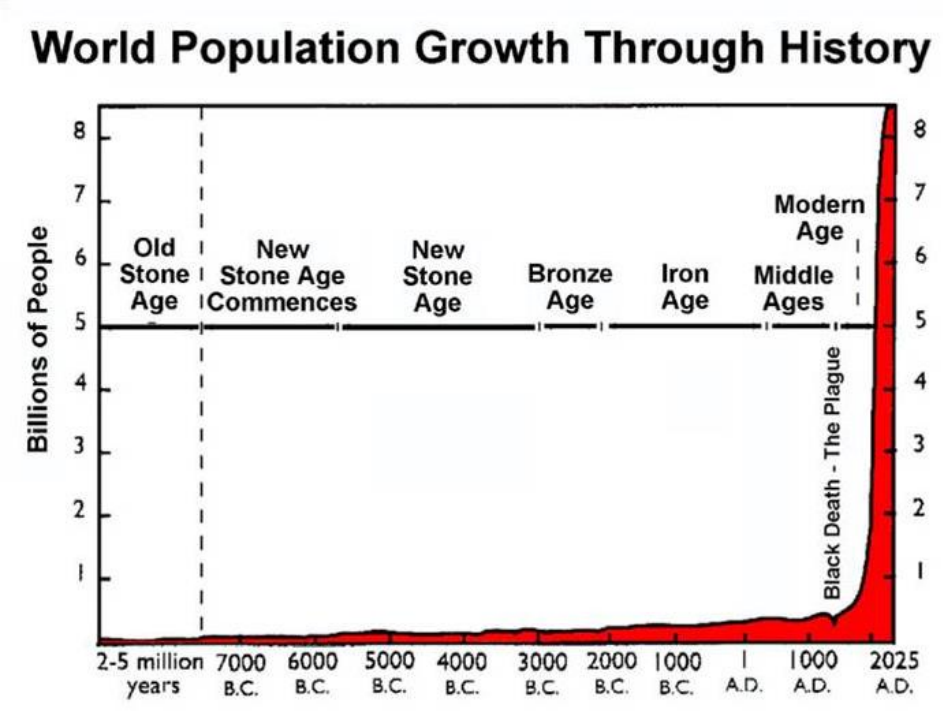
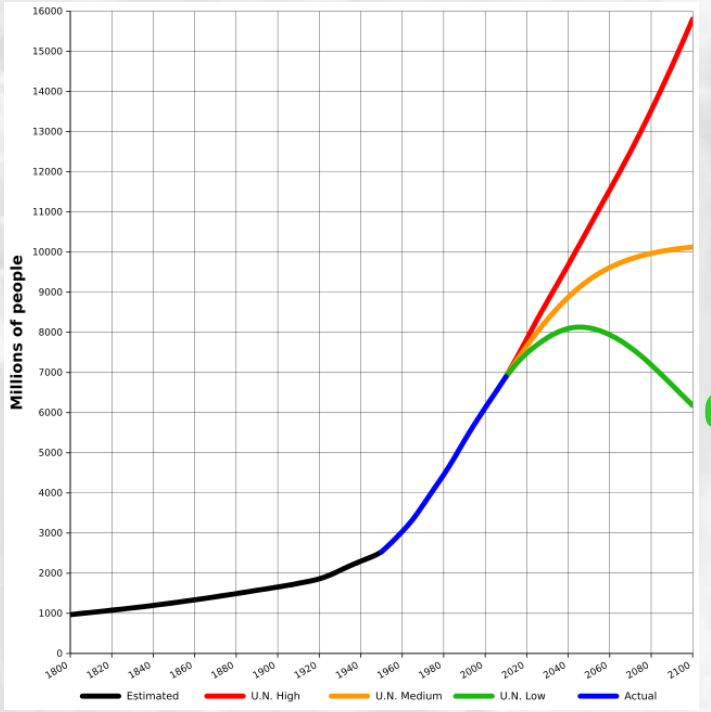
# Establishing the context for Target 9: Earth is beyond its human carry capacity

We need to feed the expanding human population!

- 7.65 billion in 2018, 78% live in developing countries (27/08/18)
- 9.8 billion by 2050, 86% in developing countries (UN, 2017)




**16 billion**

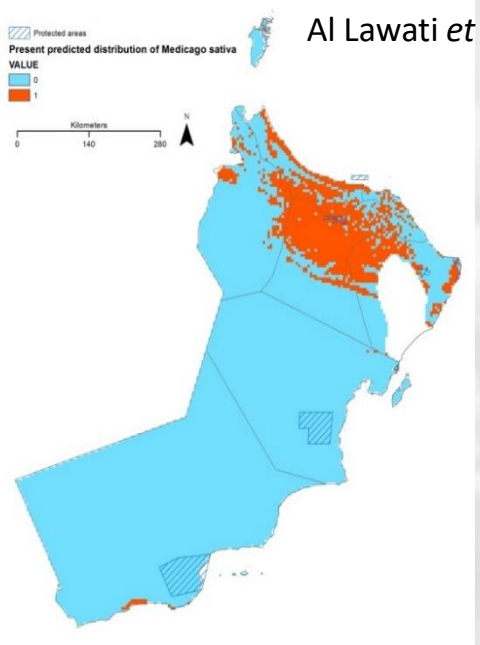
**10 billion**

**6 billion**

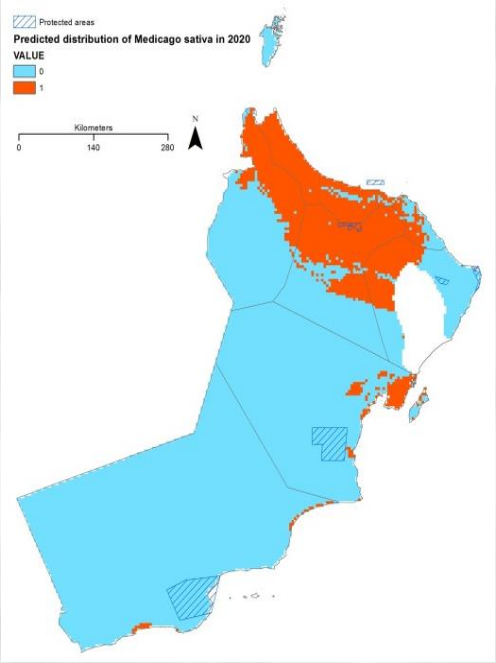
# Establishing the context for Target 9: Climate change

- To feed the human population in 2050 we will require food supplies to increase by 60% globally, and 100% in developing countries (FAO, 2011)
- While climate change may reduce agricultural production by 2% each decade this century (IPCC, 2014)

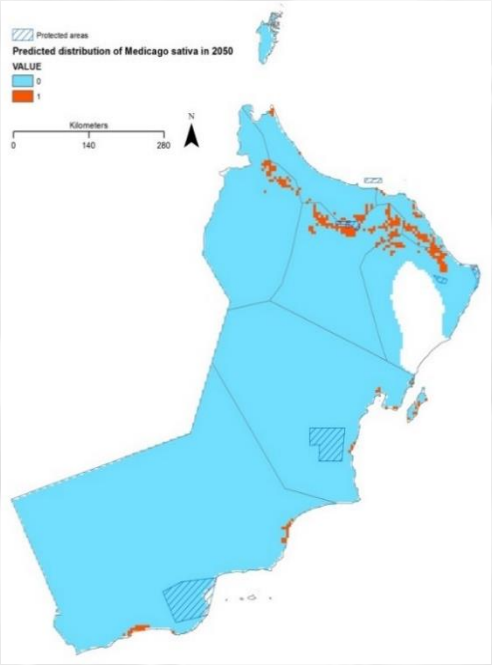
Al Lawati *et al.* (2015)




2015 @ 12%/Oman




2020 @ 17.4%/Oman




2050 @ 2.3% of Oman

# Establishing the context for Target 9: Climate change

**Breeders require trait diversity to sustain food production**

**Crop Wild Relatives (CWR) offer that diversity**

- Wide diversity of adaptive traits
- Tried, proven but still largely unapplied outside top 15 global crops
- Technological advances in application

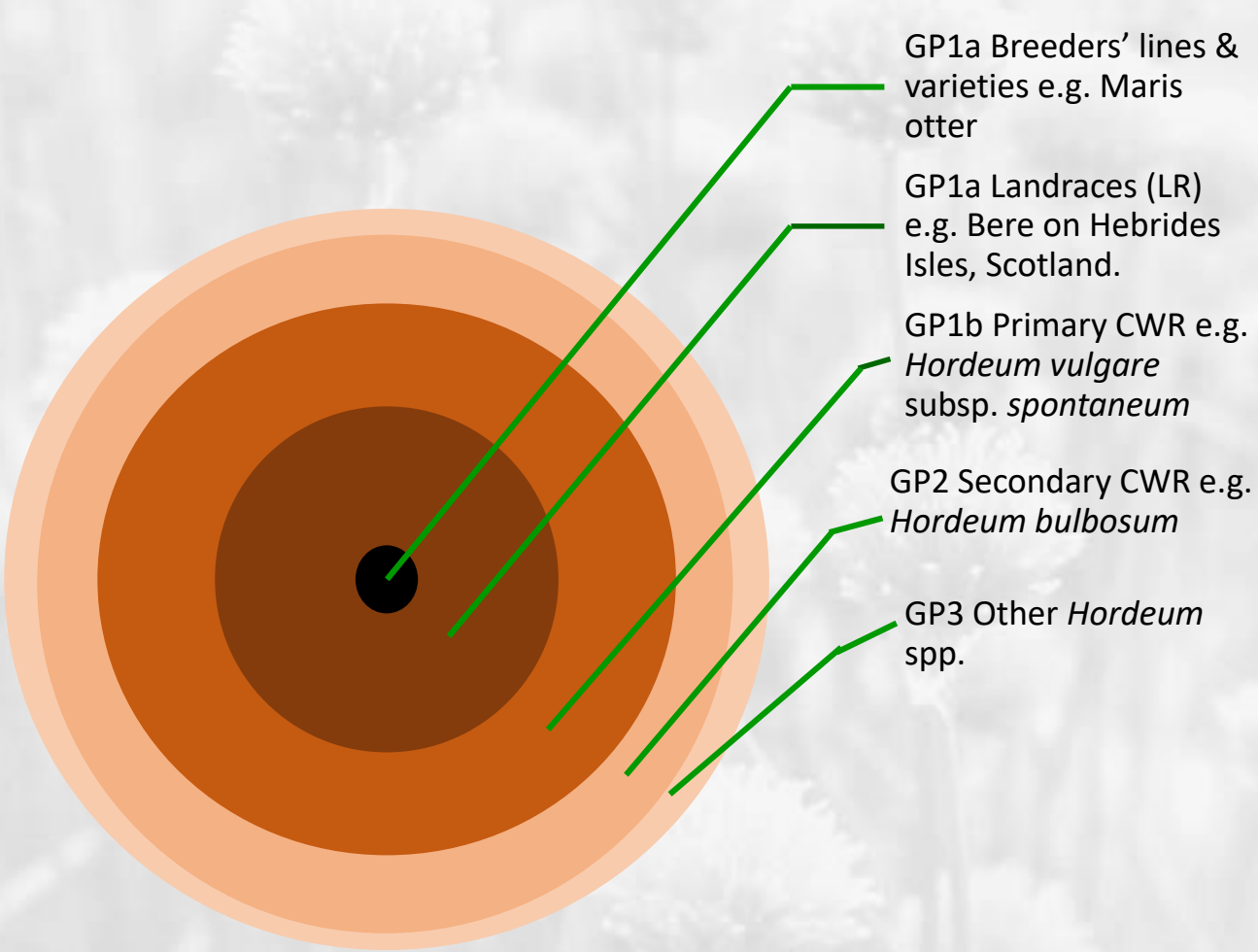
# GSPC Target 9: What does it mean?

**"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"**

- **Technical rationale: ….** "70 per cent of the genetic diversity of a crop is a reasonable target to achieve for most crop species in a relatively small sample (generally less than one thousand accessions)" …. "For some 200–300 major crops, it is likely that 70 per cent of genetic diversity is already conserved *ex situ* in gene banks. Genetic diversity is also conserved through on-farm management and active *in situ* conservation in natural ecosystems, but this is currently un-quantified"

*Beta vulgaris* subsp. *maritima*

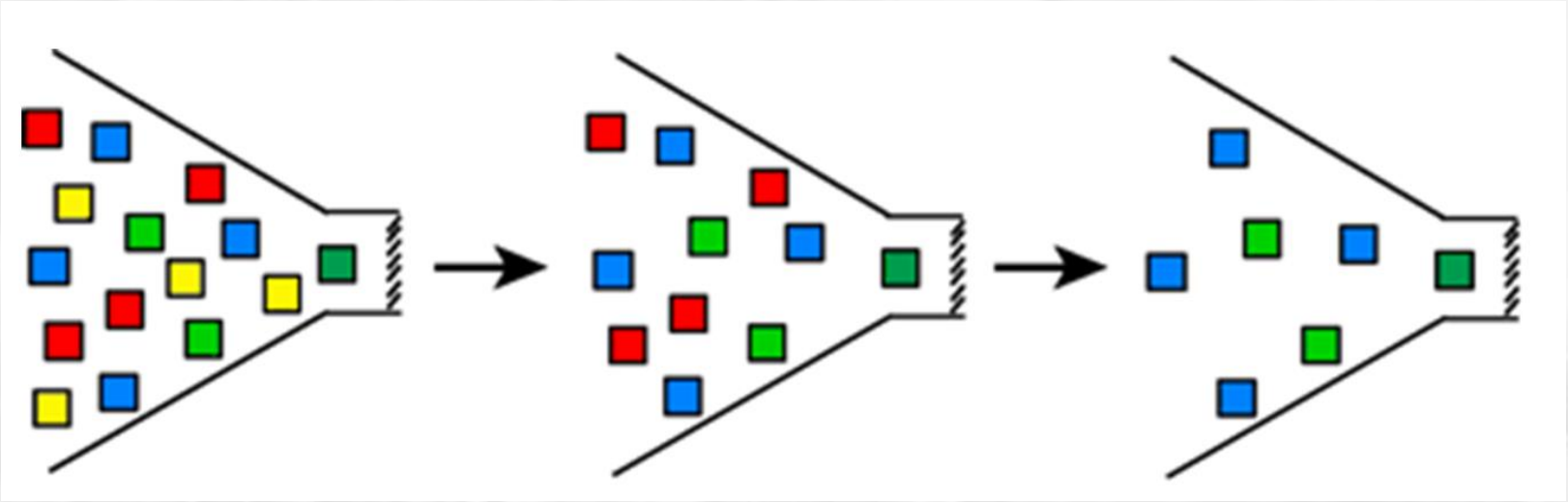
# GSPC Target 9: What does it mean?




*Hordeum vulgare* ssp. *spontaneum*

Relative genetic diversity held at each level of the barley genepool

# GSPC Target 9: What does it mean?



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)

LR and CWR contain the bulk of crop genepool genetic diversity

# GSPC Target 9: What does it mean?

Landraces are the traditional forms of crops maintained by cycles of farmer based seed saving and planting and often have evolved local unique genetic adaptation to local agro-environments

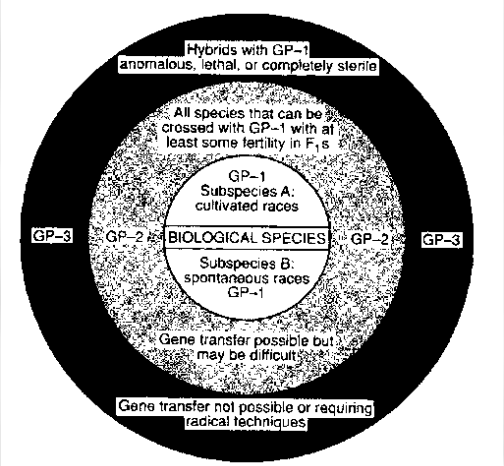
But LR are the most severely threatened component of biodiversity (Maxted, 2008)

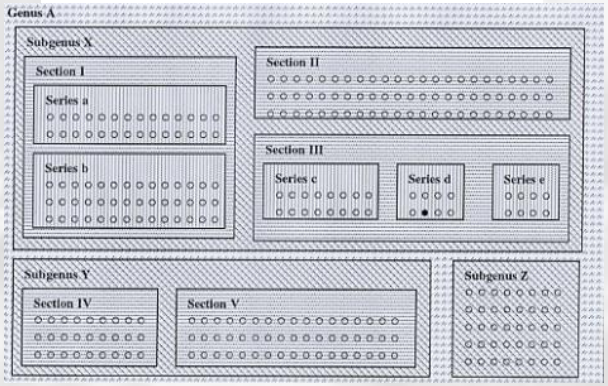
- Why?
  - We have no idea how many LR exist
  - Landrace maintainers are almost always older and their number is dwindling each year (= average age in Scottish islands is 65)
  - Farmers are by definition commercial they grow what yields the highest economic return, they are not conservationists
  - 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
  - Scottish islands survey 2003 found 30 crofters growing LR, repeated in 2018 now 2

Bere barley grown on the Hebridean Isles, Scotland

# 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




**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*

# Value of CWR: as a source of adaptive traits

| *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 |

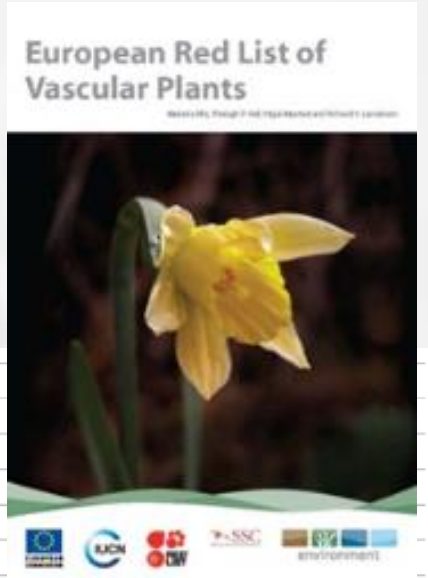
*Aegilops speltoides* (B-genome )

*Wheat*

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

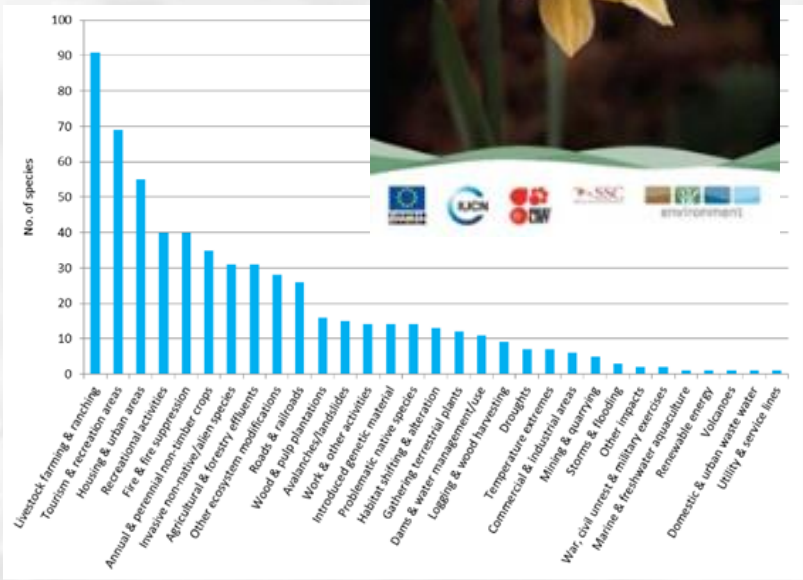
# Why crop wild relatives?

## 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




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

Yet analysis of PGR *ex situ* collections found:

- Wild (CWR) taxa represent 10.5% of total germplasm accessions
- Castañeda *et al.* (2016) reviewed global *ex situ* holdings found
  - ≈ ⅓ unconserved (no accessions in genebanks)
  - ≈ ⅓ poorly conserved (<10 accessions)
  - 72% are a high priority for collection

*In situ* CWR conservation is virtually non-existent

- Many CWR are found in existing *in situ* 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
- None meet Iriondo *et al.* (2012) standard for *In situ* CWR conservation


*In situ* and *Ex situ*

# 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."

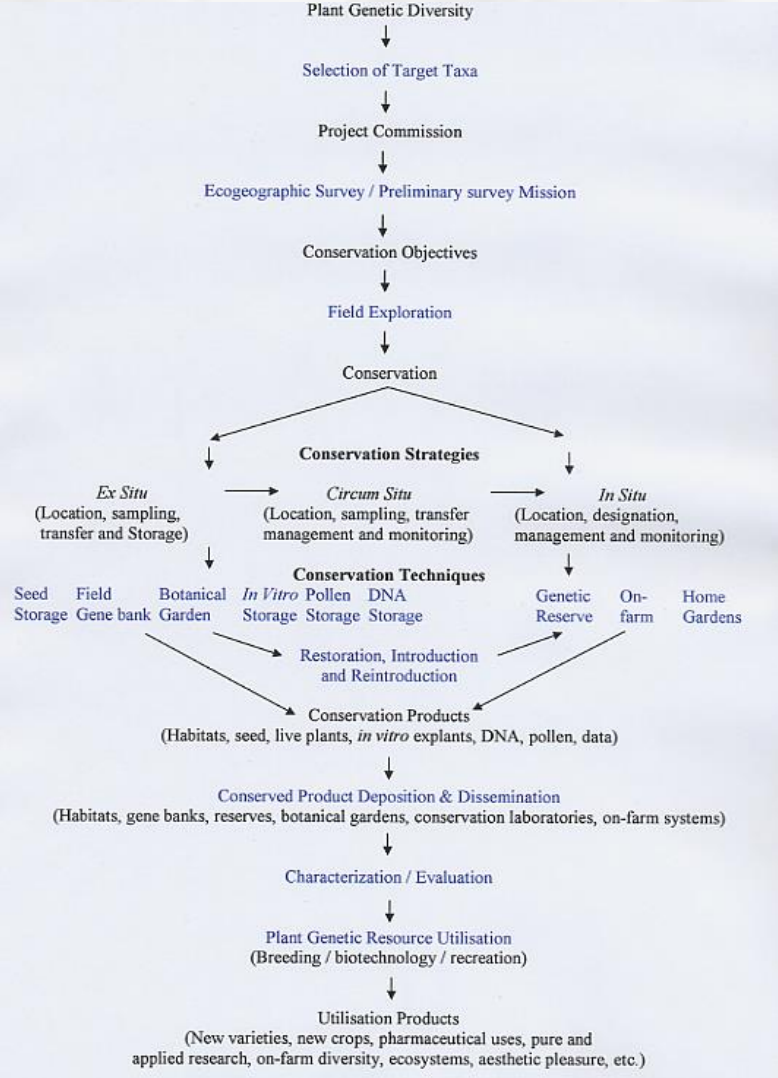

- CBD Global Strategy for Plant Conservation 2011 – 2020 (2010) – Target 9 of 16

"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

# Holistic Integration of CWR Conservation



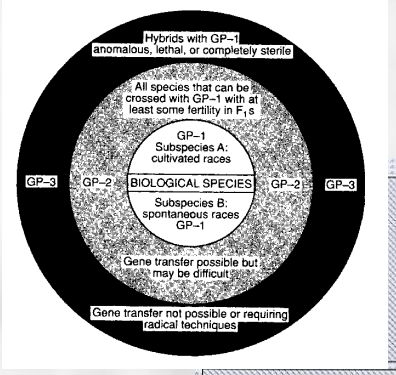

Utilitarianism + Geography

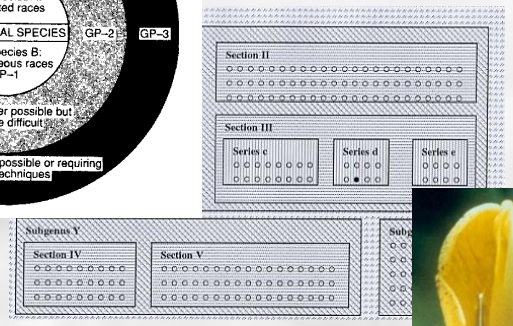
- Conservation linked to
  - Use
- National
- Regional
- Global

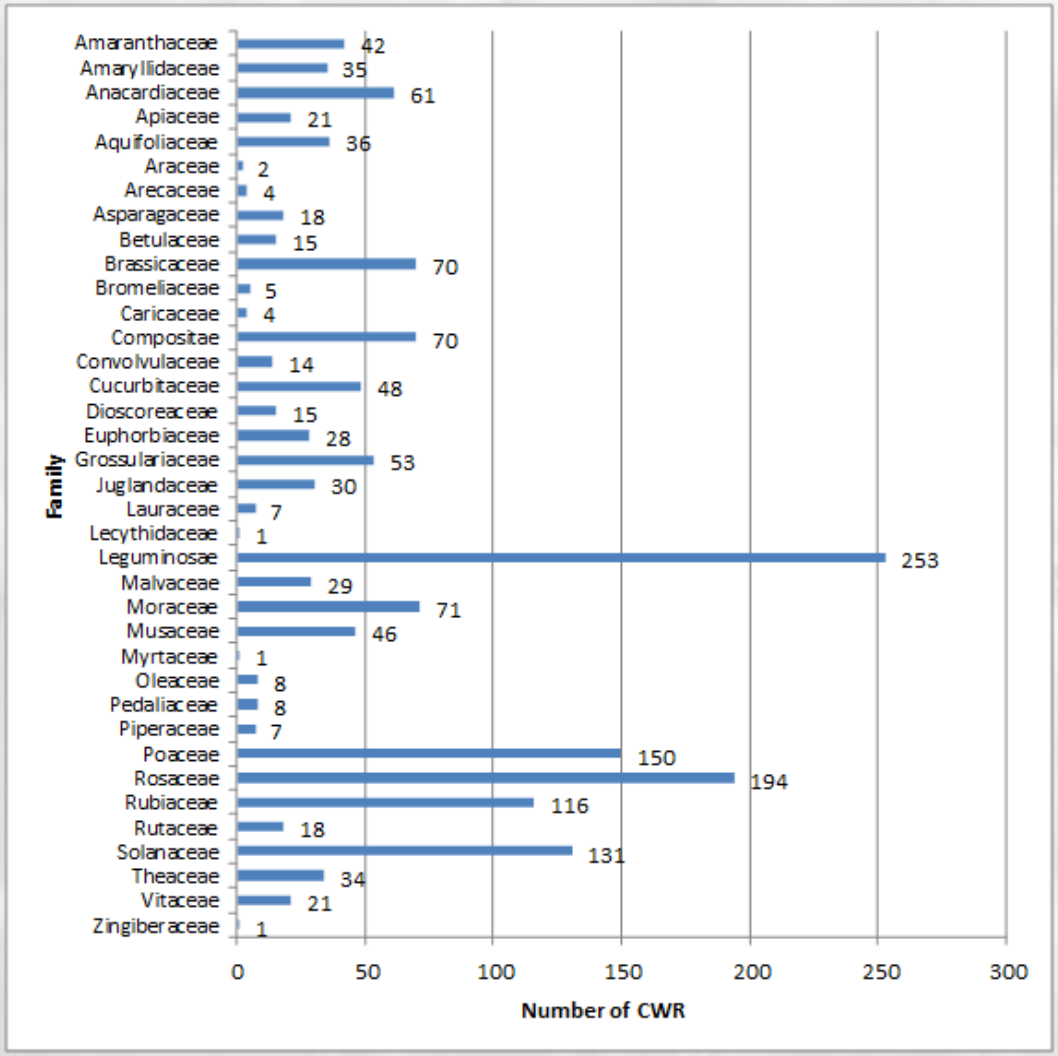
# Global CWR Conservation

- Global Crop Diversity Trust project with Norwegian Gov. funding
- Primarily use orientated, but some funding for *ex situ* collecting in first 6 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 CWR Conservation




1,667 priority CWR taxa from 194 crops

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

Vincent *et al.* (2012)

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

# Global CWR Conservation

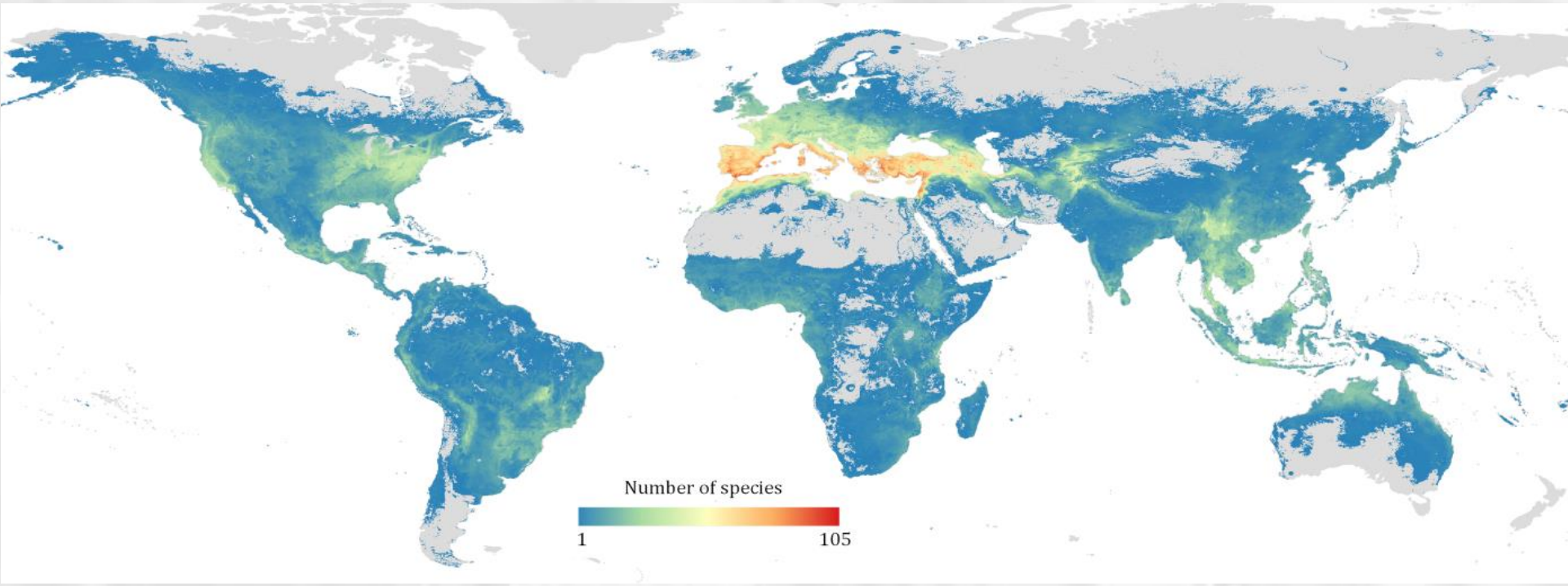



Figure 1. Species richness map for the priority 1,394 CWR related to 194 crops at five arc minutes resolution (Vincent *et al.,* 2018).

# Global CWR Conservation

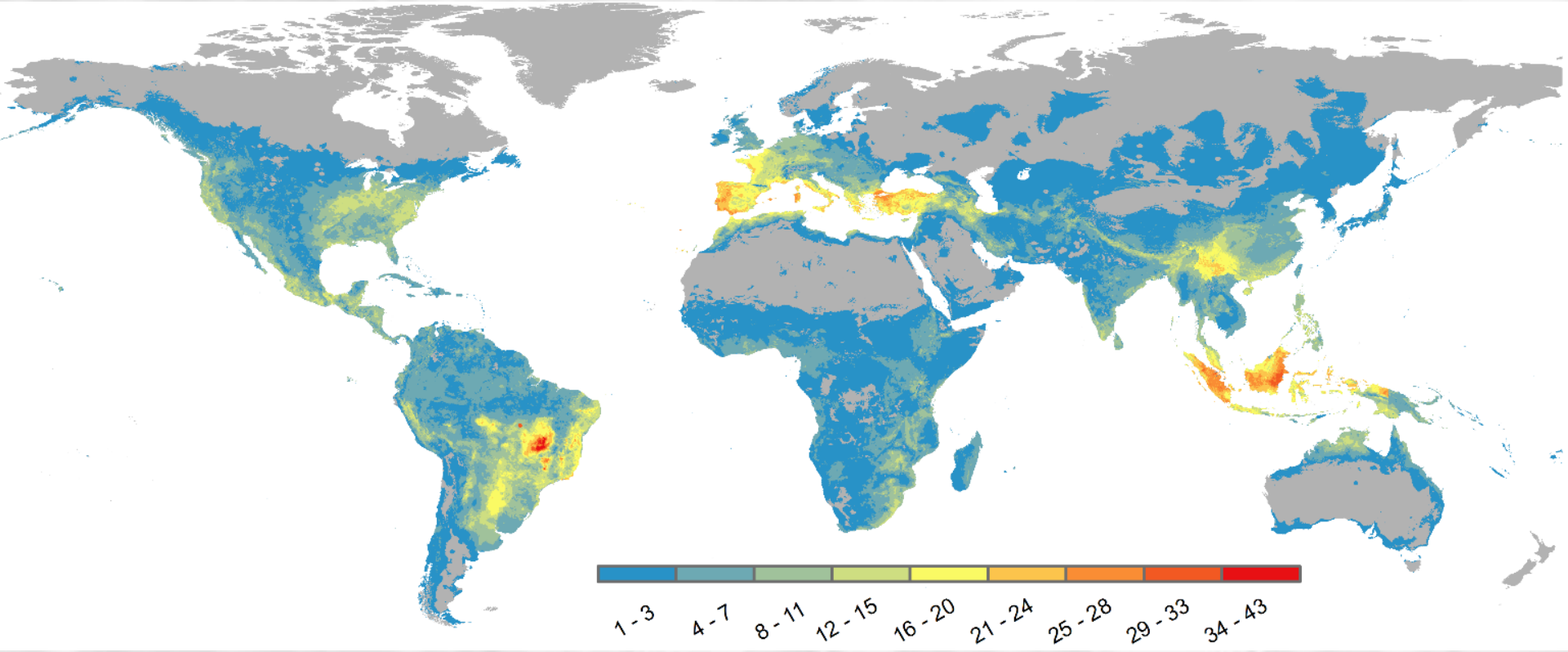
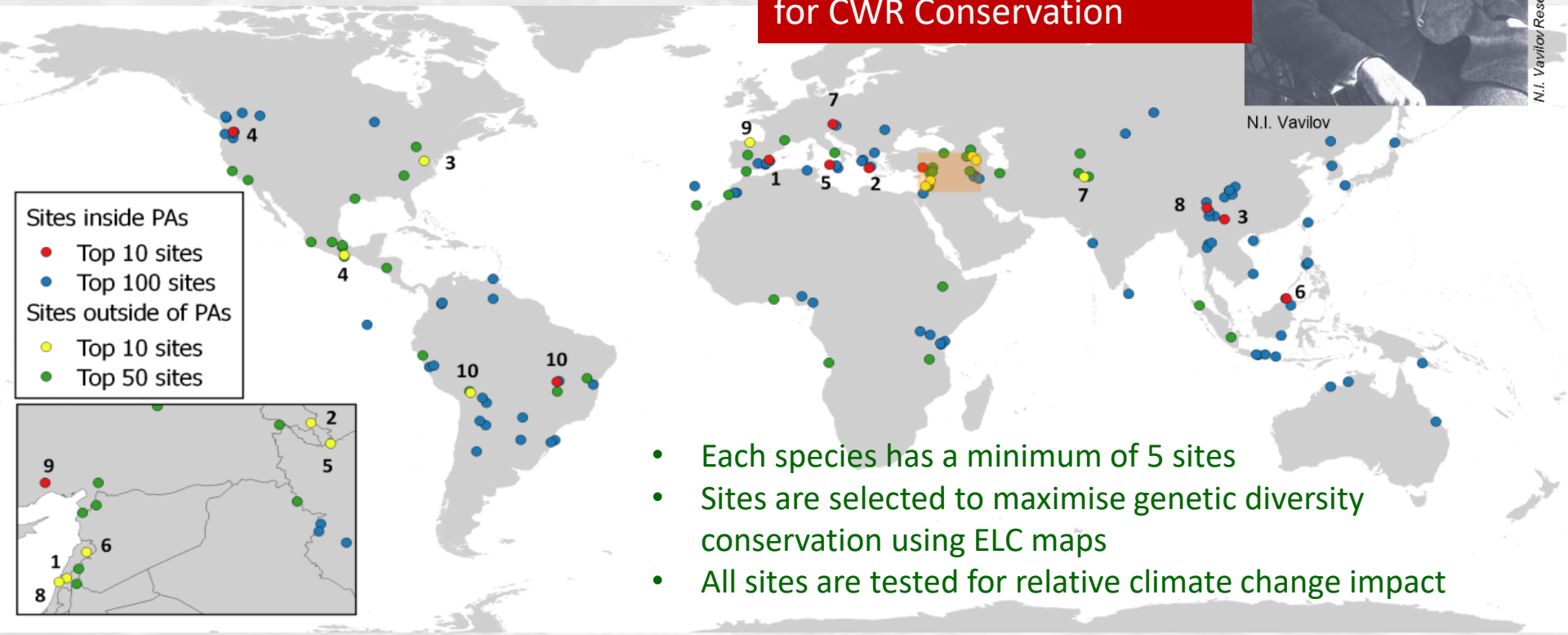



Figure 2. Global collecting hotspots for High Priority CWR for 76 crop gene pools (Castañeda-Álvarez *et al.*, 2016).

# 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

Figure 3. Top 170 sites for global *in situ* CWR conservation (100xPA and 50xnon-PA), with magnification on the Fertile Crescent and Caucasus (Vincent *et al.,* 2018).

# GSPC Target 9 Report Card

- 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 genetic diversity
  - Breadth of gene pools
  - How 70% is defined
  - *In situ* and *ex situ* genetic conservation