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GBIF helping to underpin food security

J Magos Brehm, Åsmund Asdal, Nora P. Castañeda, Sónia Dias, Samantha Dobbie, Ehsan Dulloo, Ruth J. Eastwood, Dag Endresen, Hannah Fielder, Brian Ford-Lloyd, Luigi Guarino, José Iriondo, Shelagh Kell, Mauricio Parra-Quijano, Jade Phillips, Maria Luisa Rubio, Imke Thormann, Holly Vincent, John Wiersema, Nigel Maxted

THE GBIF PUBLIC SYMPOSIUM 2014, New Delhi, 17 September 2014

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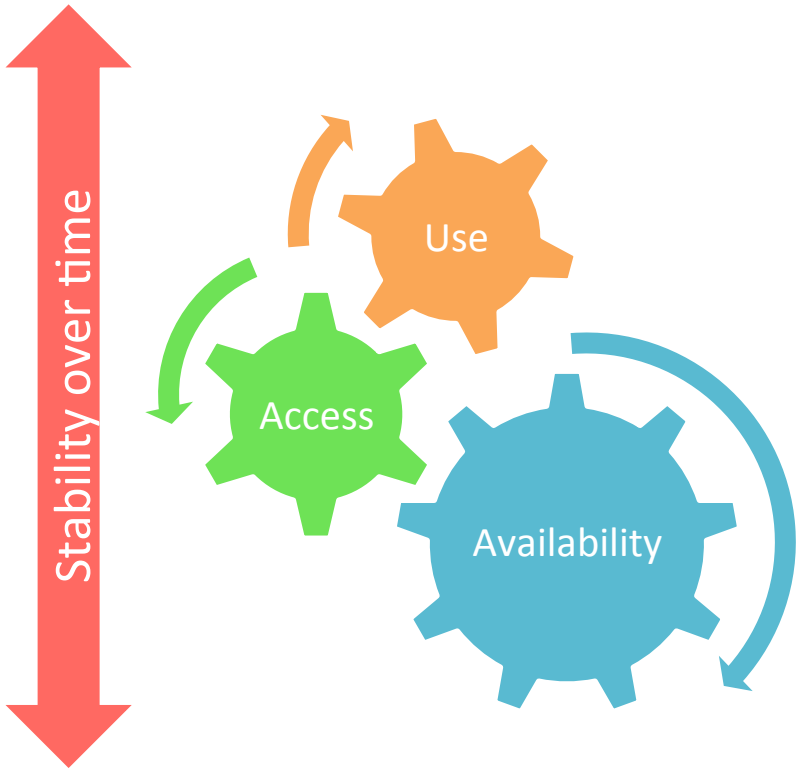
Contents

- Food security / insecurity
- Crop wild relatives
- National strategies for conservation of crop wild relatives
- How do we use GBIF-mediated data?
- Examples
- Recommendations
- Conclusions

Food security

‘Food security exists when all people, at all times, **have physical, social and economic access to sufficient, safe and nutritious food**, which meets their dietary needs and food preferences for an active and healthy life (...) The **nutritional dimension** is integral to the concept of food security.’

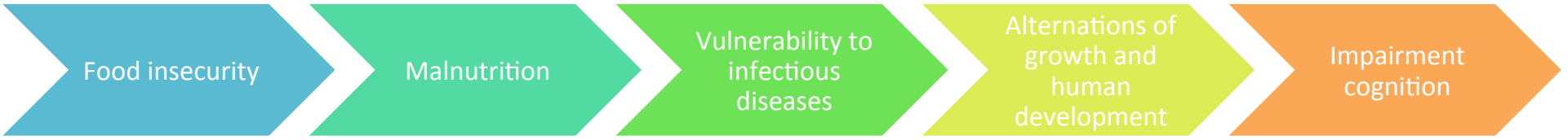
(World Food Summit FAO 2009)



Food insecurity

'A situation that exists **when people lack secure access to sufficient amounts of safe and nutritious food for normal growth and development and an active and healthy life** (...) Food insecurity, poor conditions of health and sanitation and inappropriate care and feeding practices are the major causes of poor nutritional status."

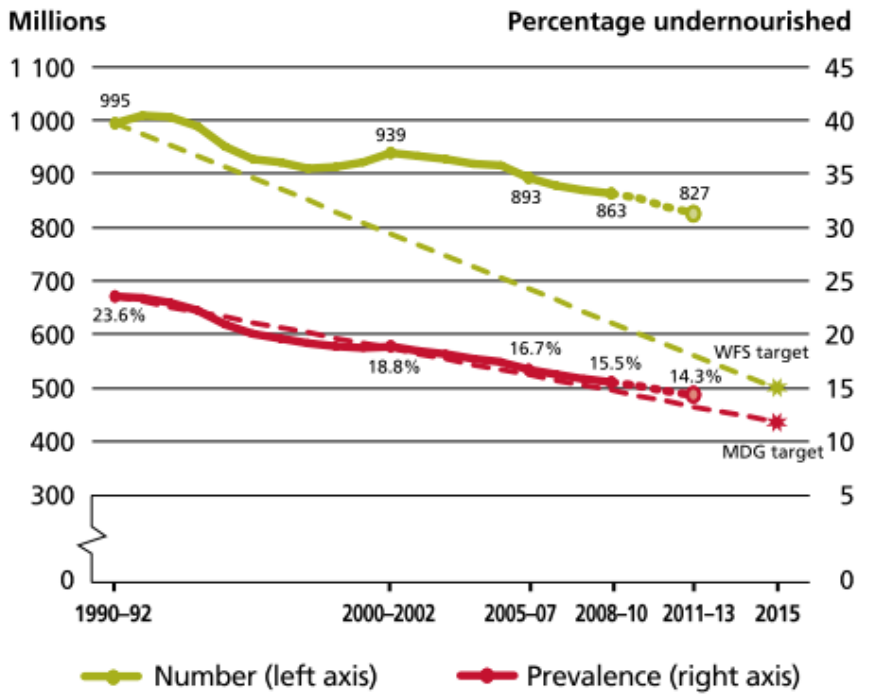
(The State of Food Insecurity in the World 2013)



Food insecurity – the present

- 7.26 billion (Sep 2014)
- 842 million (1 in 8) suffering from chronic undernourishment (2011-2013)

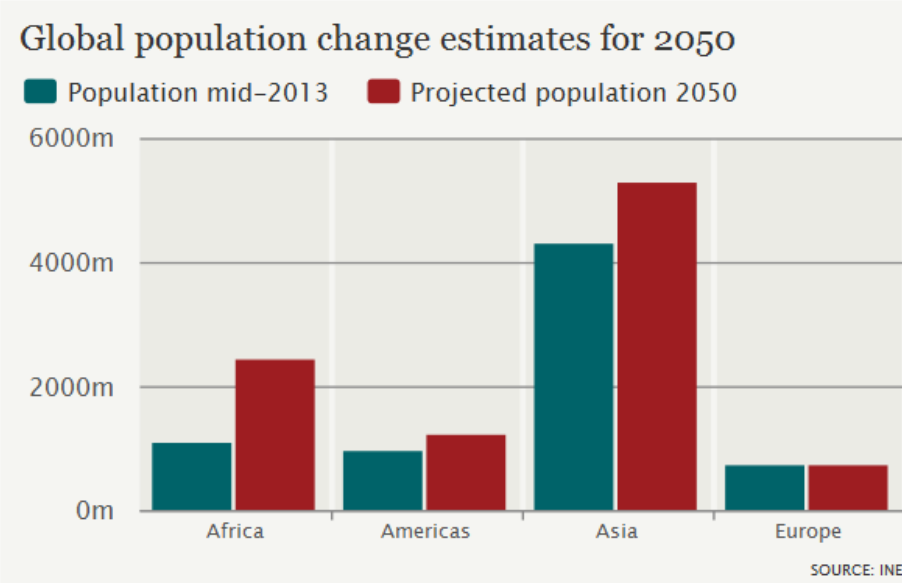
Undernourishment in the developing regions: actual progress and target achievement trajectories towards the MDG and WFS targets

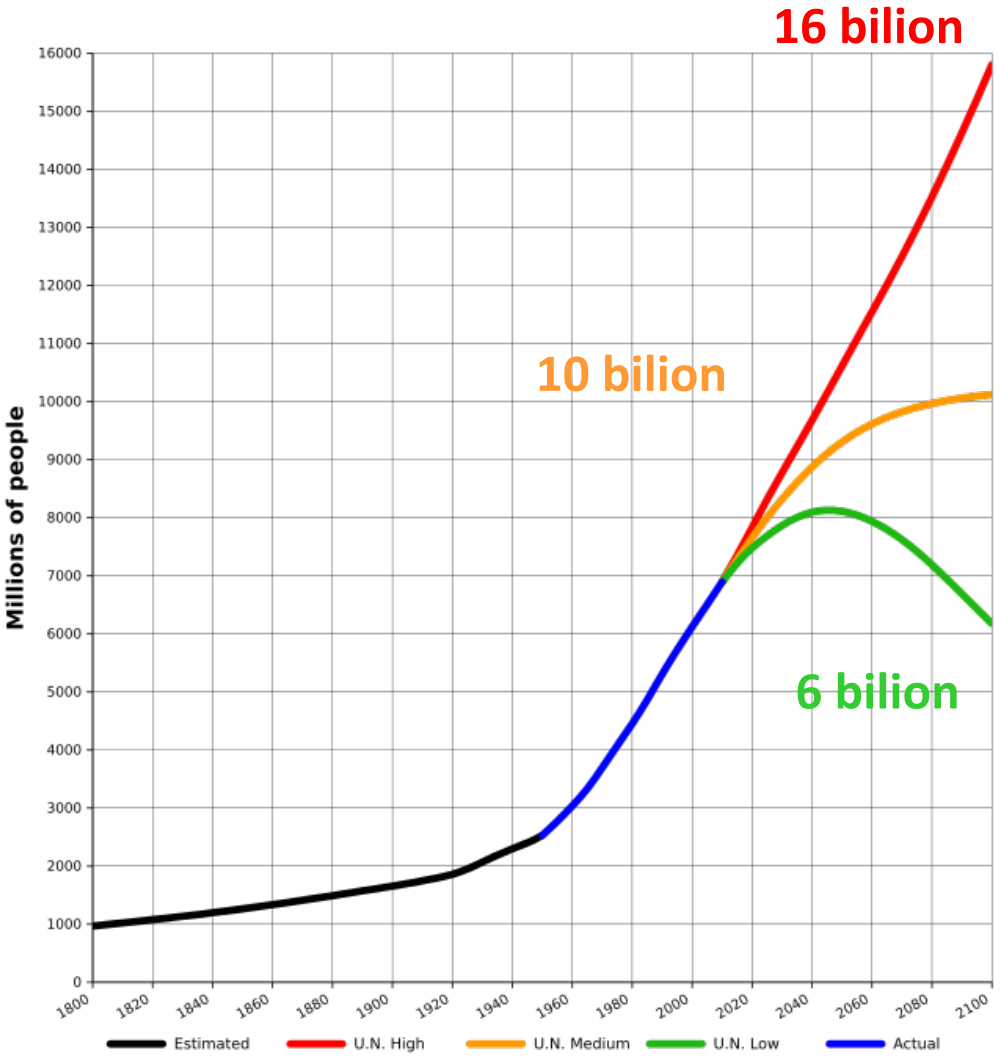


Note: Data for 2011–13 in all graphics refer to provisional estimates.
Source: FAO.

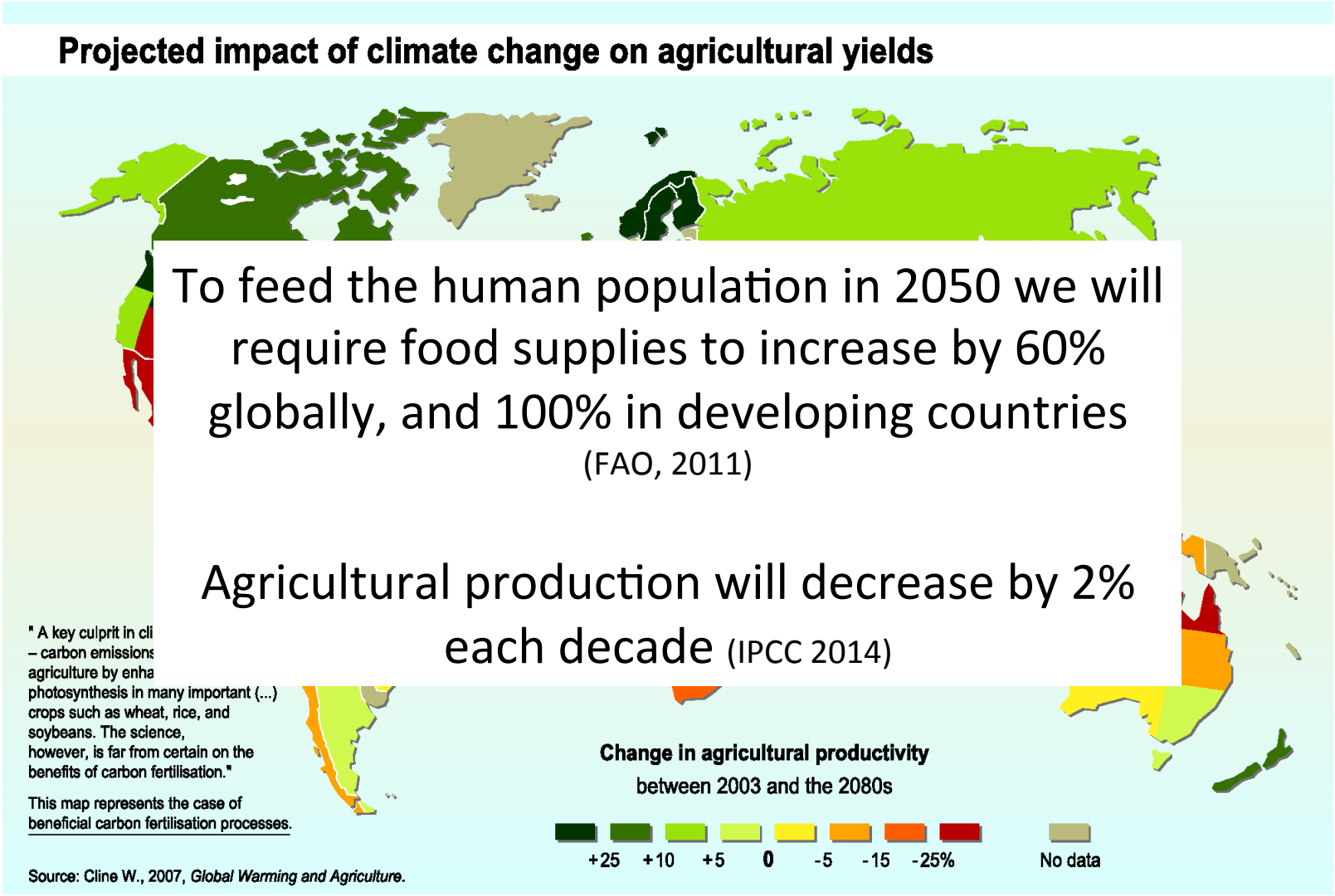
Food insecurity – the future?...

9.6 bilion by 2050 (UN 2013)





Food insecurity – the future?...



To feed the human population in 2050 we will require food supplies to increase by 60% globally, and 100% in developing countries (FAO, 2011)

Agricultural production will decrease by 2% each decade (IPCC 2014)

Food insecurity – some solutions

- Achieve re ces itself from one
- Reduce fo
- **Sustainab**
- **Improve l**
- **Shift agric**
- **Boost cro**
- **Improving**
- Policy cha
- Etc…

WE NEED CROPS:

- with higher yields
- with higher nutritional value
- adapted to degraded lands
- adapted to changing environments

CROP WILD RELATIVES!

(World Resources Institute 2013, www.sustainabletable.org)

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

Beta maritima

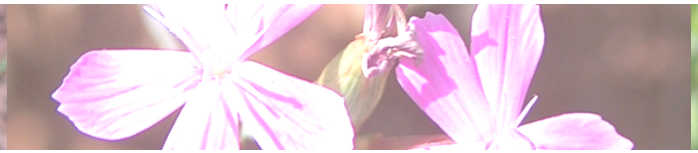
Beta vulgaris (sugarbeet)

Value of CWR: as source of adaptive traits

Crop	CWR	Application(s)
Barley (*Hordeum vulgare*)	*H. spontaneum*	Drought and temperature tolerance
Sweet potato (*Ipomoea batatas*)	*I. trifida*	Root knot nematode and root lesion nematode resistance
Lettuce (*Lactuca sativa*)	*L. serri*	…ce
	L. viros	
Tomato (*Lycopersicon esculentum*)	*L. chee… peruvi…*	…nce, drought and salinity …s, insect resistance
	L. chile	…l virus
	L. chmi	
	L. hirsu	…bility
	L. pimpinellifolium	Wilt causing fungus
		Quality control characters
	L. pimpinellifolium	Fruit size and shape
	L. pimpinellifolium	Disease resistance, early maturity, determinate growth habit, parthenocarpy, soluble solids
Cassava (*Manihot esculenta*)	*M. aesculifolia*	Robustness
	M. angustiloba	Drought tolerance

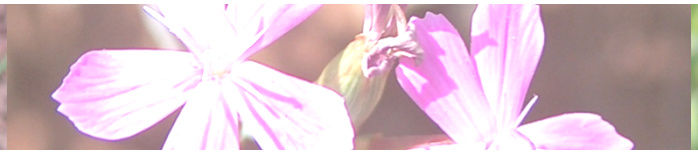
$115 billions toward crop yields per year
(Pimentel *et al.* 1997)

(Maxted and Kell 2009)


Why conserve CWR?

- CWR account for around 21% of the world's flora (Maxted and Kell 2009)
- Their natural populations are becoming more threatened - **2 out of 10!** (Kell *et al.* 2012)



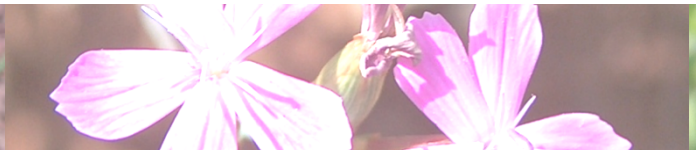
Are CWR already conserved?

- *Ex situ* conservation – currently inadequate:
  - Only 5.6% of *ex situ* PGR accessions reported by EURISCO are CWR (http://eurisco.ecpgr.org/)
  - 24,448 accessions of 1,095 species
  - < 7% of EU CWR

In situ conservation of CWR

- Found in existing PA but not monitored and actively managed
- Very few examples of active *in situ* CWR conservation:
  - *Triticum* spp. in Ammiad, Eastern Galilee, Israel
  - *Aegilops* spp. in Ceylanpinar of South-east Turkey
  - *Zea perennis* in the Sierra de Manantlan, Mexico
  - *Citrus*, *Oryza* and *Alocasia* spp. in Ngoc Hoi, Vietnam
  - *Solanum* spp. in Pisac Cusco, Peru
  - Grain CWR in the Erebuni Reserve near Yerevan, Armenia
  - *Phaseolus* spp. in Costa Rica
  - *Coffea* spp. in the Mascarene Islands

Genetic reserve, Al-Haffe, Syria (photo: Nigel Maxted)

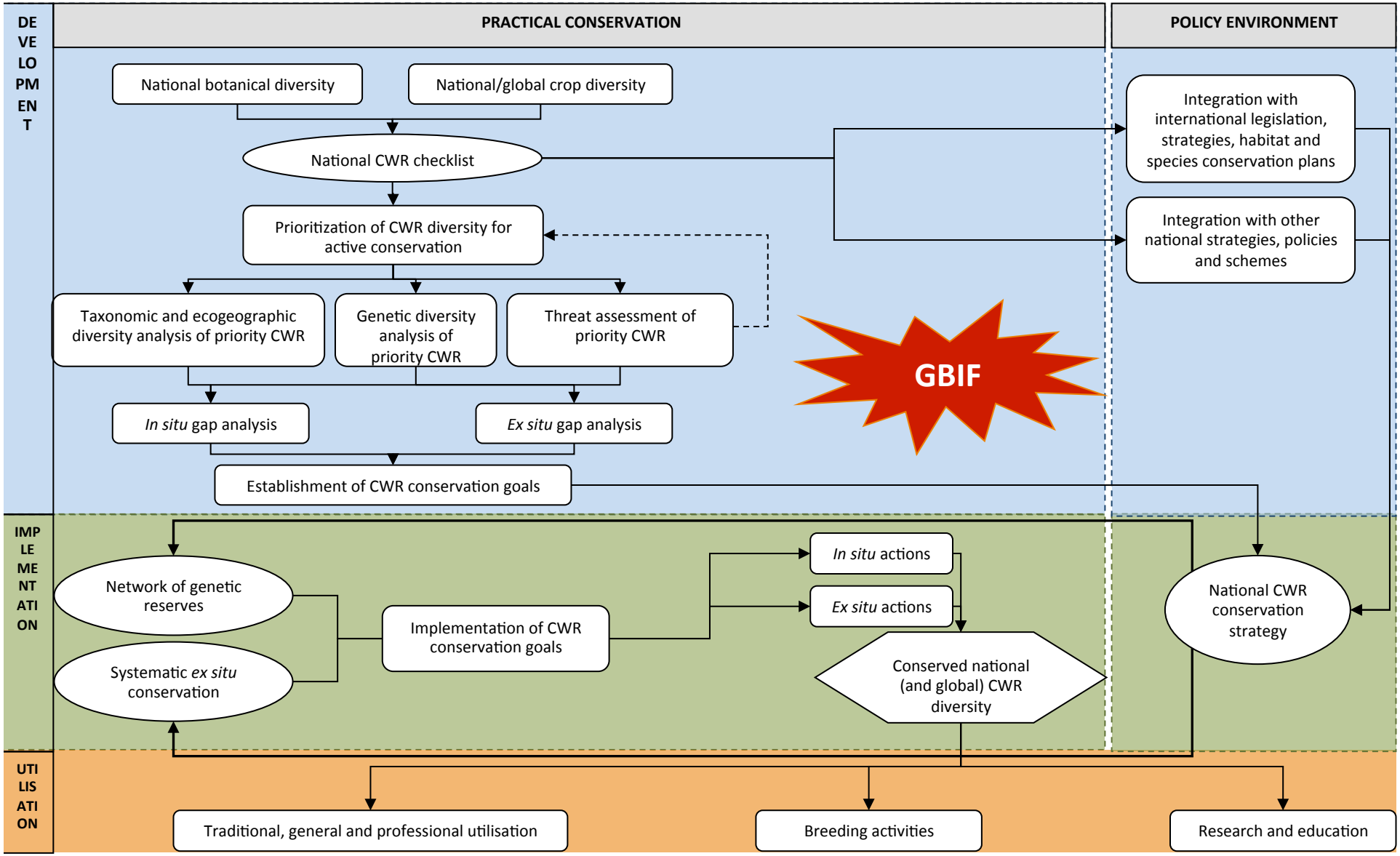




National strategies for the conservation of CWR

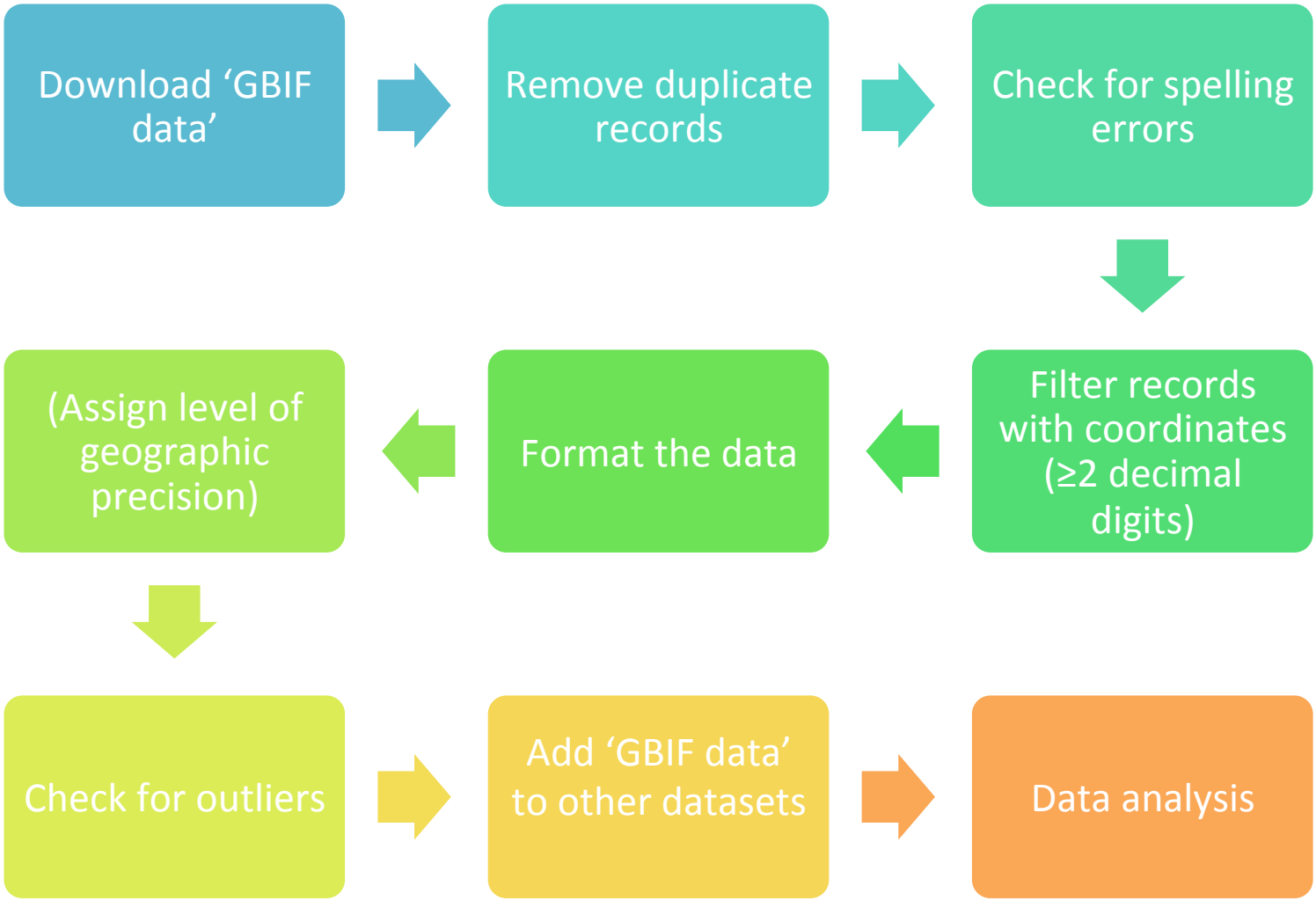
- unique national resource
- threatened
- legislative requirement to conserve
- require an integrated *in situ* / *ex situ* approach, best implemented via a National CWR Strategy
- no single method of generation

Maxted *et al.* 2007, 2013

National strategies for the conservation of CWR



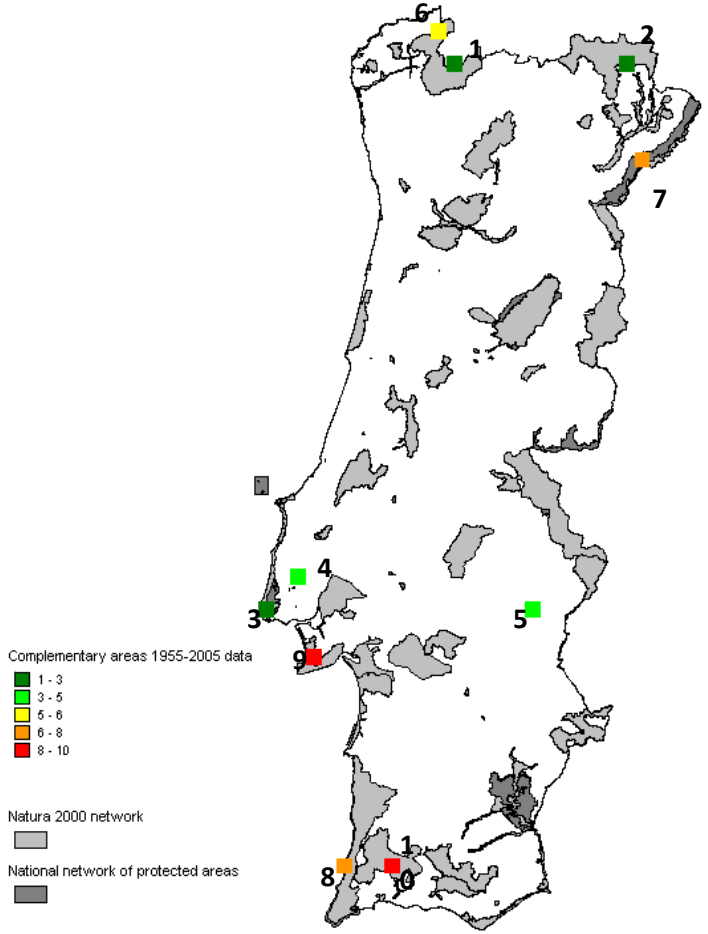
How do we use GBIF-mediated data?



Complementary sites that conserve priority CWR in Portugal

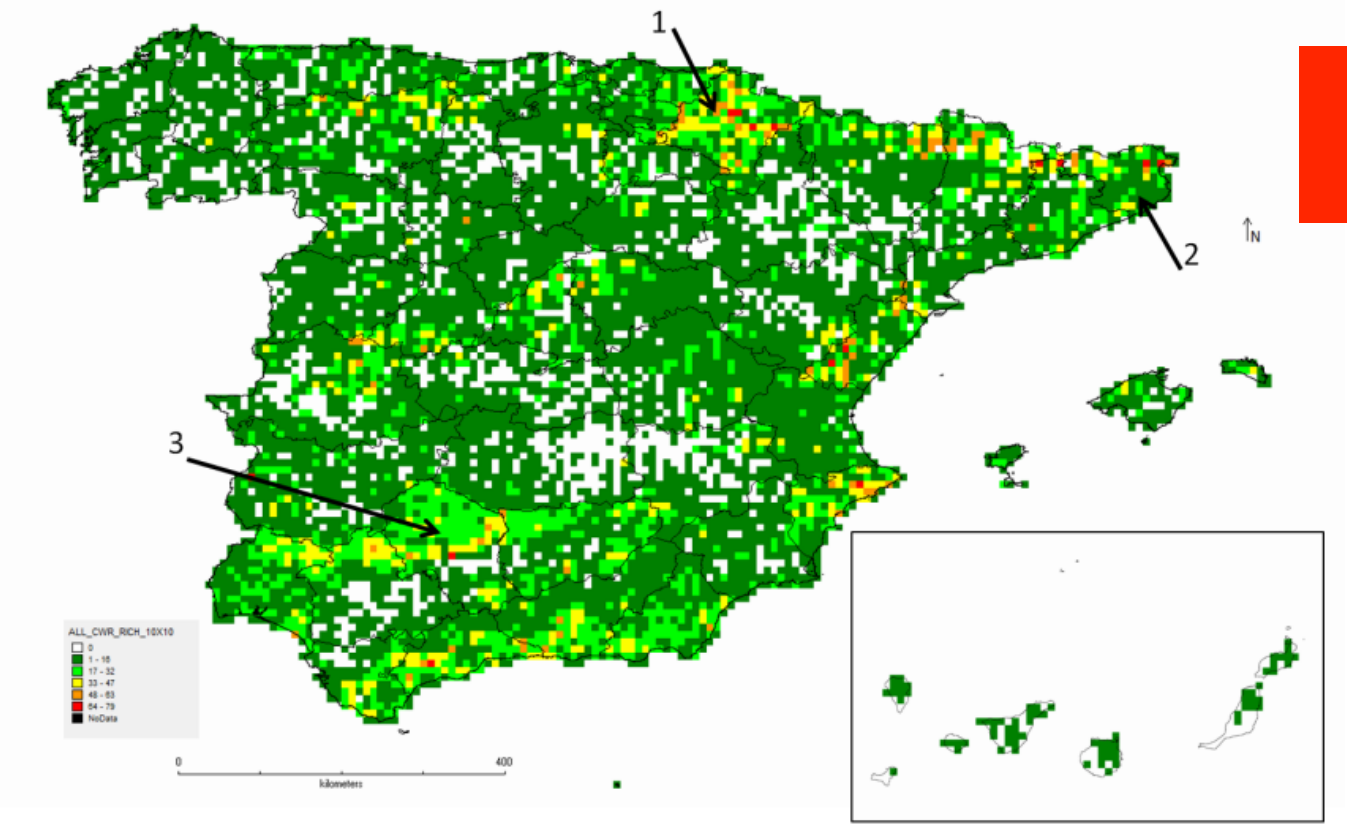
20 priority CWR Portugal

- **32 records** from GBIF
- **9 sites with 18 priority CWR**



Magos Brehm 2009

National strategy for the conservation of CWR of Spain

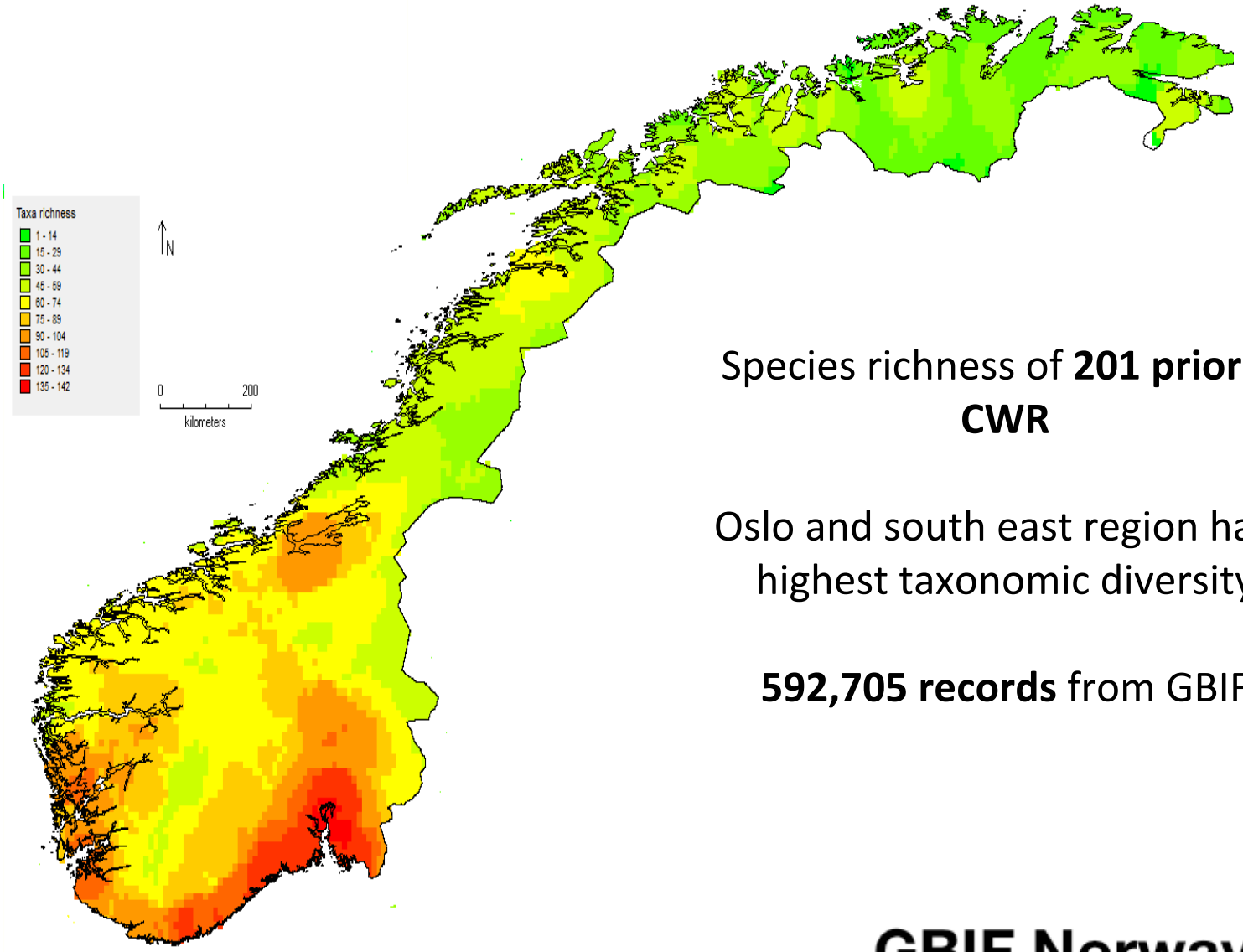


HOTSPOTS

Figure 13: Hotspot areas (10 x 10 km) for all CWR species in the Spanish National Inventory. Red areas encompass the highest number of CWR species. The numbers point to locations where the highest number of species is found (Provinces where locations are found: 1=Navarra, 2=Girona, 3=Córdoba).

Rubio Teso *et al.* 2014

CWR diversity in Norway



Species richness of **201 priority CWR**

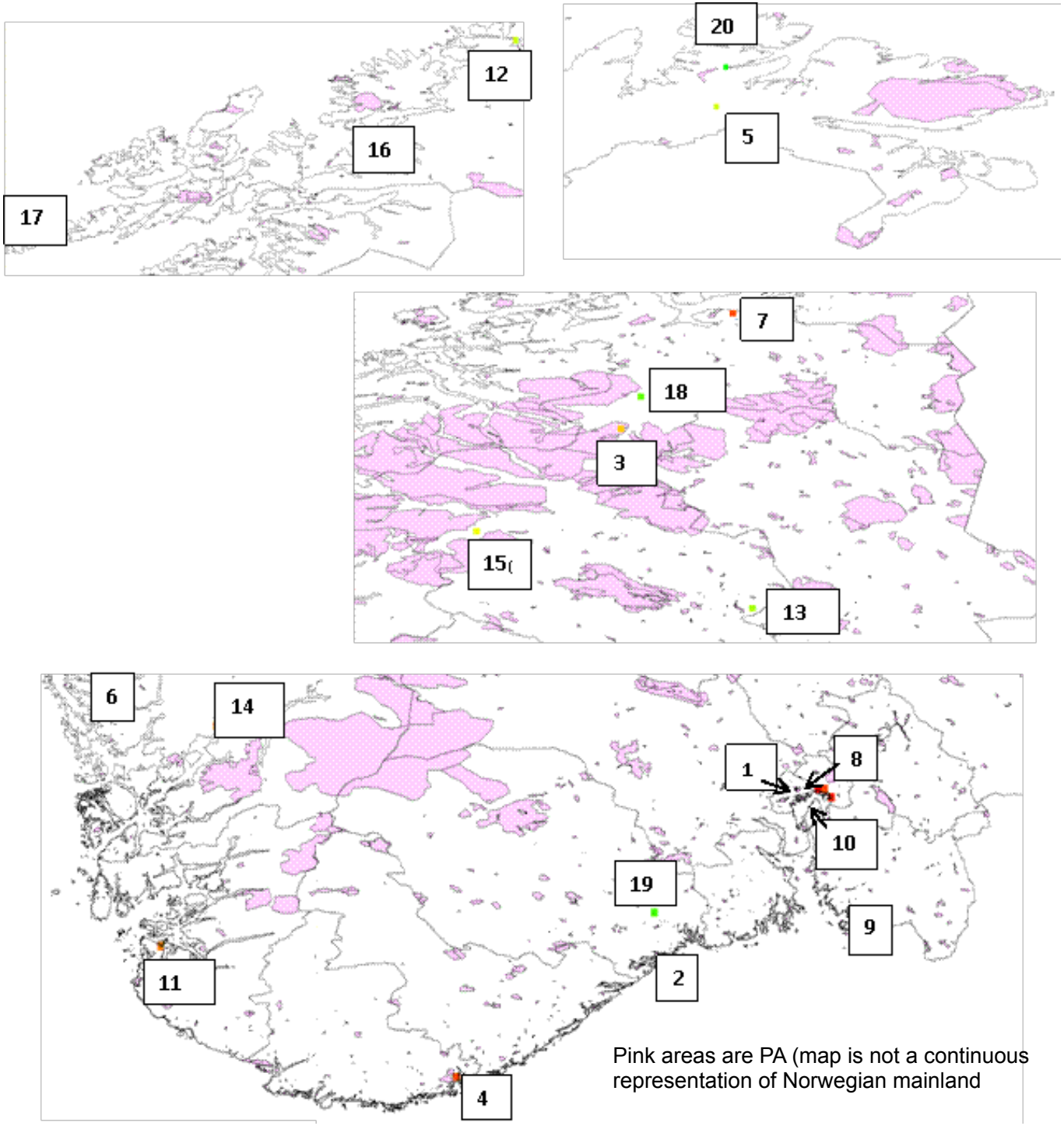
Oslo and south east region have highest taxonomic diversity

592,705 records from GBIF

Phillips *et al.* In prep.

GBIF Norway

CWR diversity in Norway



Pink areas are PA (map is not a continuous representation of Norwegian mainland

COMPLEMENTARY SITES – 20 to cover 201 priority CWR

Amplified Fragment Length Polymorphisms (AFLP) - to determine if taxonomic diversity is correlated with genetic diversity.

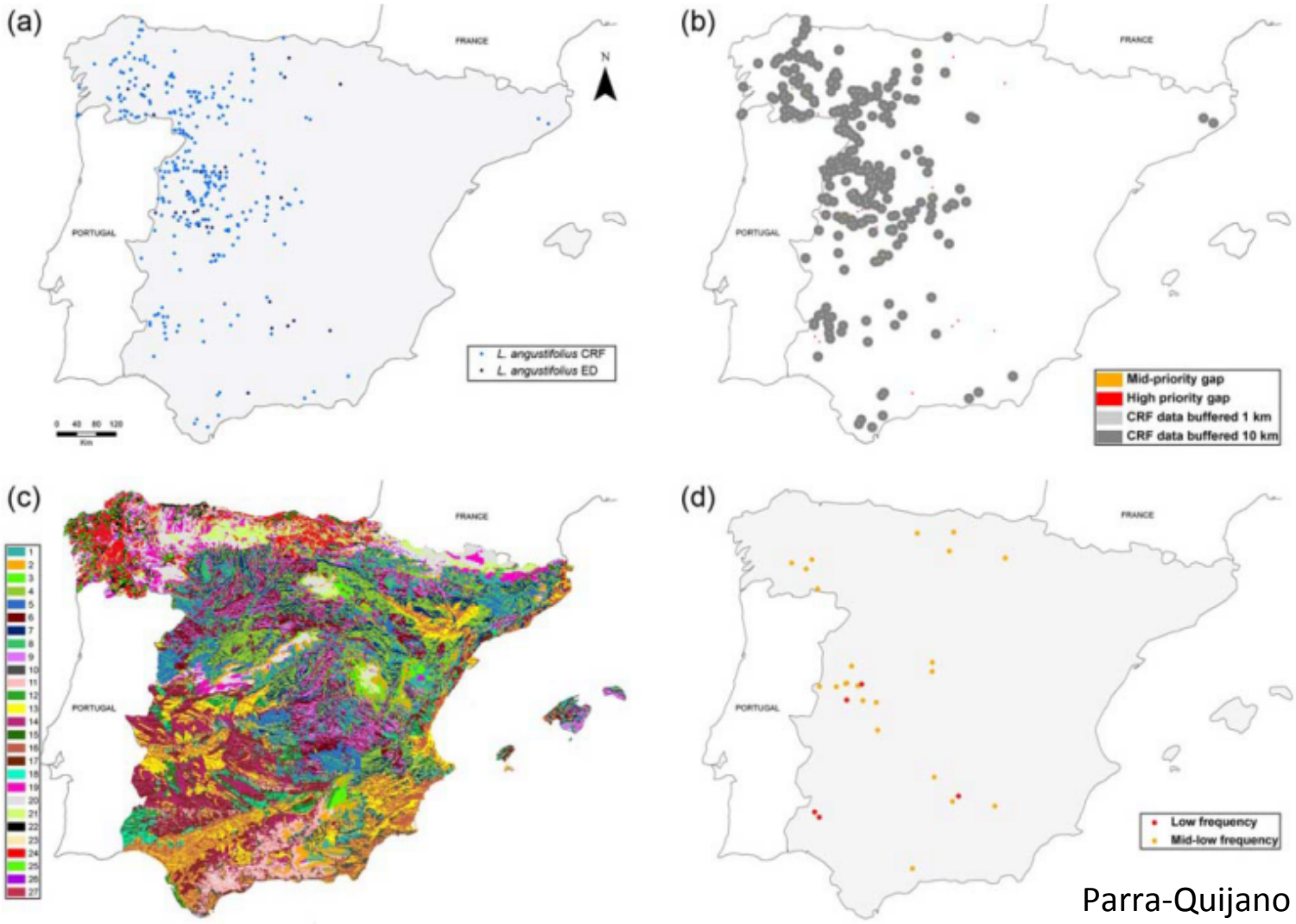
Phillips *et al.* In prep.

Improving representativeness of genebank collections of Spanish *Lupinus*

- To detect under-represented ecogeographic diversity through gap analysis
- It is the basis for optimized germplasm collecting strategies

1. Ecogeographic land characterization (ELC) map created reflecting adaptive scenarios – *Lupinus* sp.
2. Species occurrences were superimposed on ELC map and ecogeographic categories (EC) extracted for each point
3. Species occurrences (genebank vs. other sources) are compared (gaps)
4. Select under-represented and priority EC (based on their frequency in existing accessions)
5. Spatial gaps were detected
6. Predicted distribution of *Lupinus* spp.
7. Sites for further collecting : priority spatial-ecogeographical gaps + high probability area for ≥ 1 *Lupinus* spp.

Improving representativeness of genebank collections of Spanish *Lupinus*



Parra-Quijano *et al.* 2011

Global CWR conservation – *Adapting agriculture to climate change: collecting, protecting and preparing CWR*

Global Crop Diversity Trust project with Norwegian Gov. funding (USD 50 milion)

1. 81 crop gene pools selected (1187 CWR)
2. Ecogeographic data collection (**> 150,000 records** from GBIF)
3. Gap analysis using Maxted *et al.* (2008), Ramírez-Villegas *et al.* (2010) methodology

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MILLENNIUM SEED BANK PROJECT
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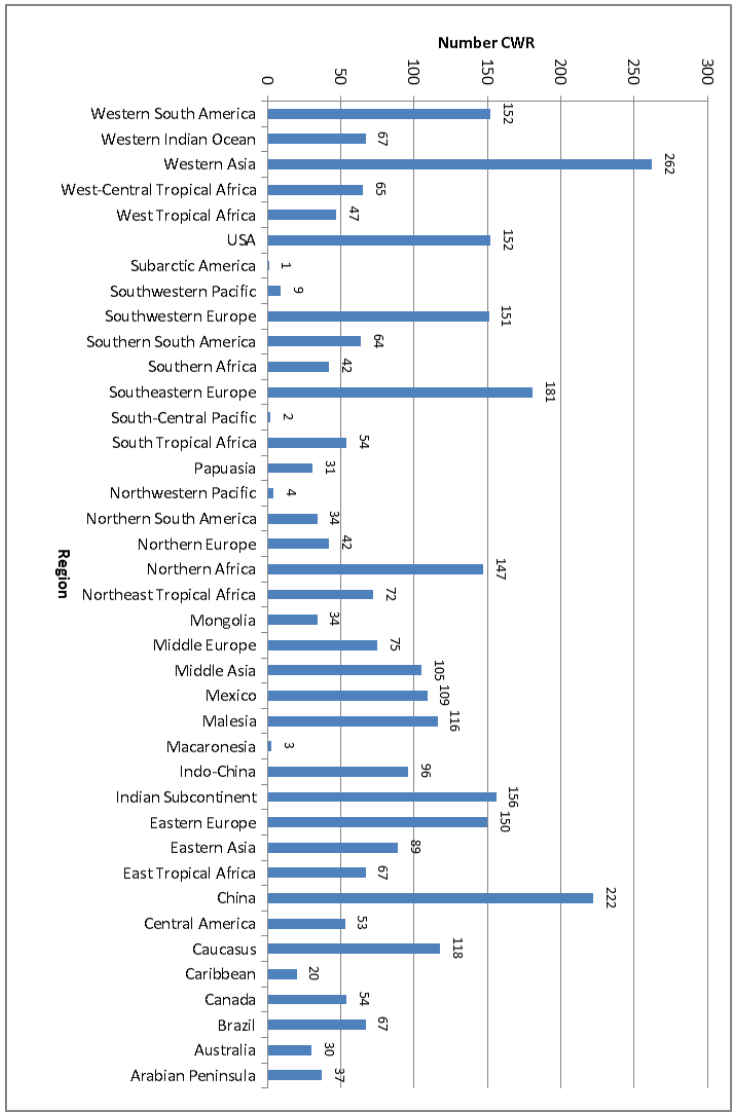
Global CWR conservation – *Adapting agriculture to climate change: collecting, protecting and preparing CWR*

4. Field collection (countries)
5. *Ex situ* storage (national genebanks, MSB, Svalbard)
6. Prepare CWR for use in breeding crops for new climates ('pre-breeding')
7. Evaluate them for useful traits
8. Make the resulting information widely available.

Global Priority CWR inventory (Vincent *et al.* 2012)



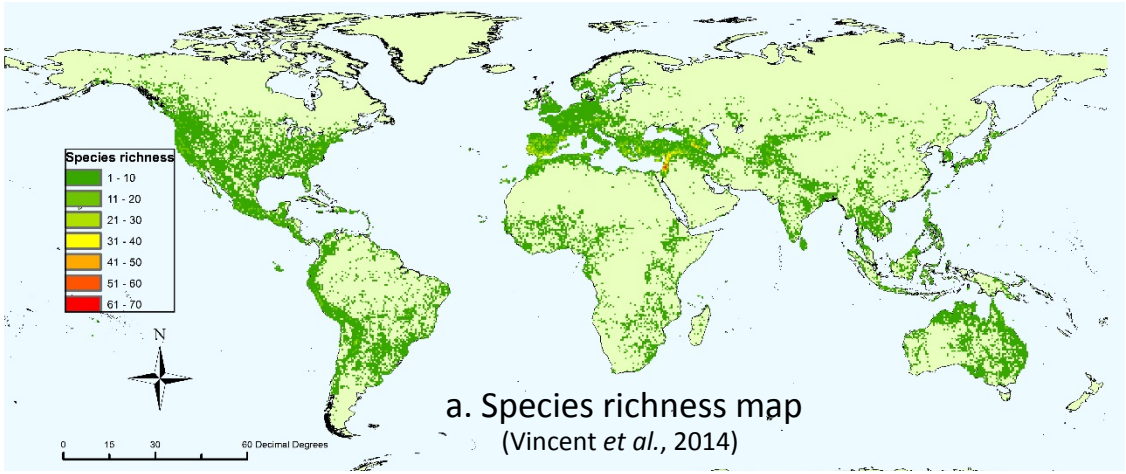
Based on ease of use and threat identified:

1,667 priority CWR taxa from 194 crops

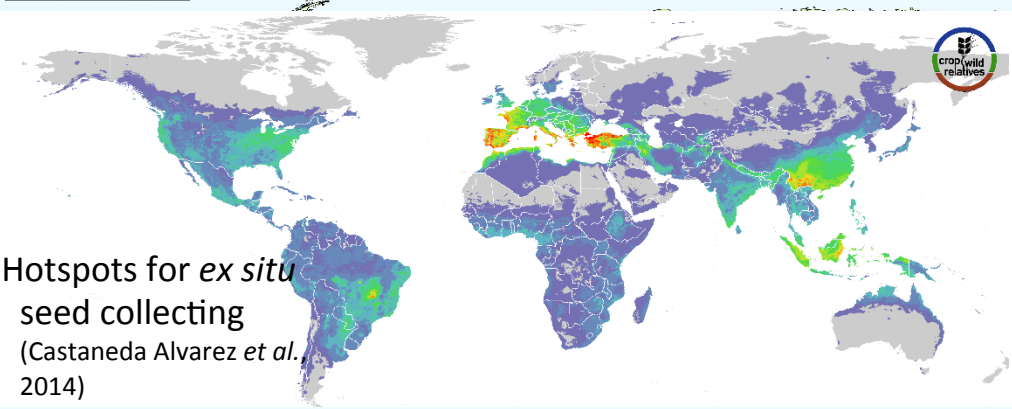
- 37 families
- 109 genera
- 1,392 species
- 299 sub-specific taxa

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

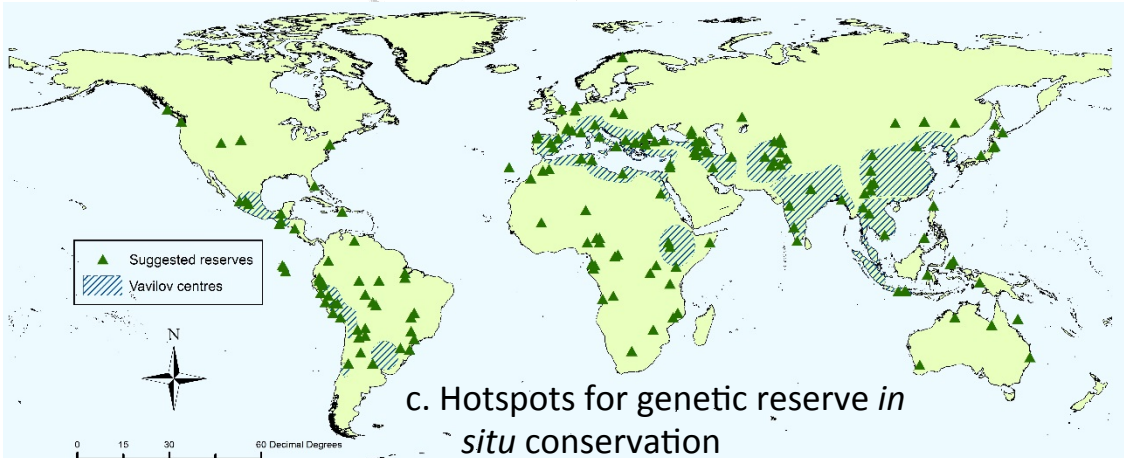
Where to conserve priority CWR diversity?



a. Species richness map
(Vincent *et al.*, 2014)



b. Hotspots for *ex situ* seed collecting
(Castaneda Alvarez *et al.*, 2014)

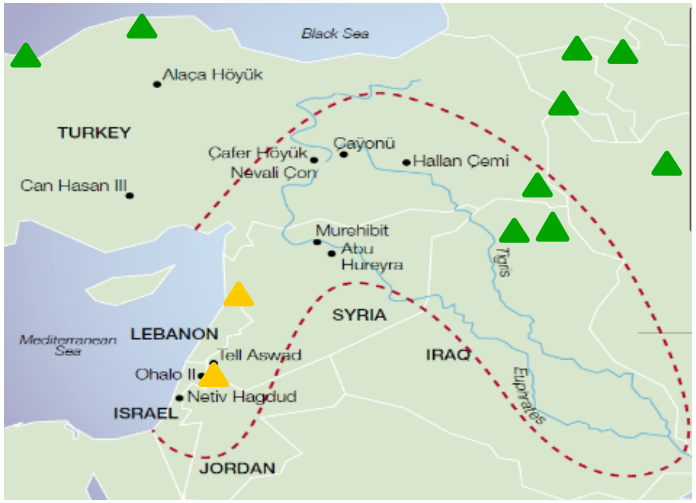


c. Hotspots for genetic reserve *in situ* conservation
(Vincent *et al.*, 2014)

71% of all taxa are in **urgent need of collection** and conservation in genebanks

www.cwrdiversity.org/distribution-map

d. Fertile Crescent



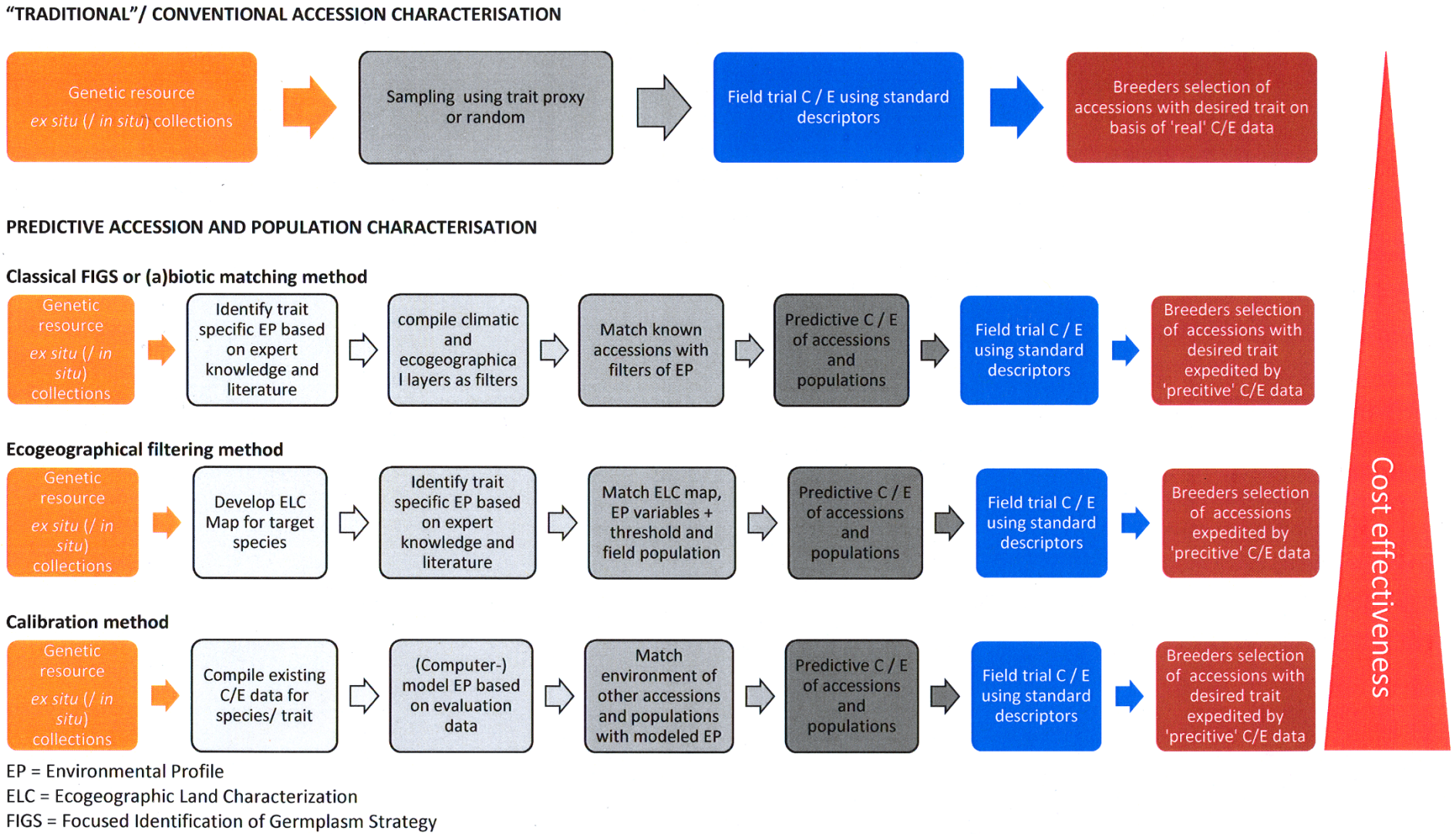
Half of temperate priority CWR species are found exclusively in the Fertile Crescent

Conservation linked to use - predictive characterization of CWR

- Optimizes the search for populations and accessions with adaptive traits when characterization and evaluation data is lacking or incomplete
- Based on geographic location and ecogeographic data
- Assumes relationship between trait and environment of occurrence site

18,859 (out of 31,745) European records from **GBIF** for *Avena*, *Beta*, *Brassica*, *Medicago* (and *Patellifolia*)

Conservation linked to use - predictive characterization of CWR



EP = Environmental Profile
ELC = Ecogeographic Land Characterization
FIGS = Focused Identification of Germplasm Strategy

Recommendations

- Improve structure of data
  - There are an excess of georeferencing fields ('georeferencedBy', 'hasGeospatialIssues', 'georeferenceRemarks', 'locationAccordingTo', etc.) which are mostly incomplete
  - Split 'Locality' in several Administrative levels (e.g. GADM administrative structure, http://www.gadm.org)
  - Locate all georeferencing fields together (locality description, coordinates and quality fields) (and not in alphabetical order)
  - Explain how to use georeferencing quality fields such as 'CoordinateAccuracy'

Recommendations

- Improve quantity and quality of CWR data
  - Georeference records without coordinates
  - Make coordinates more accurate where possible
  - Remove low quality records
- Better worldwide representation
- Integration of other sources of data (EURISCO, ENSCONET, etc…)

Recommendations

- More actively engineer data submitted to GBIF to be better quality - working with donors
- Review how GBIF users use data so supply better service
- Provide tools to help users exploit data.

Conclusions

- Increased awareness of the importance of CWR conservation and use
- CWR are a threatened and neglected resource that are likely to become increasingly important for food security in the face of climate change
- *In situ* and *ex situ* CWR conservation is currently inadequate
- Strategic approaches have been developed and tested nationally, regionally and globally
- GBIF-mediated data have been recurrently used
- High quality georeferenced data are highly important for CWR conservation planning

Acknowledgements

- EU Seventh Framework Programme, THEME KBBE.2010.1.1-03, 'Characterization of biodiversity resources for wild crop relatives to improve crops by breeding', Grant Agreement no. 266394 (*PGR Secure* project - work on Spanish CWR and predictive characterization)
- Fundação para a Ciência e Teconologia (Portuguese CWR)
- INIA (Ministry of Science and Innovation) project RF2004-00016-00-00 (work on *Lupinus*).
- Norwegian Forest and Landscape Institute - Norwegian Genetic Resource Centre (work on Norwegian CWR)
- Norwegian Government (project '*Adapting agriculture to climate change: collecting, protecting and preparing CWR*' - work on global *in situ* and *ex situ* conservation of CWR)

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