Predictive characterization: an introduction

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Regional training workshop

Predictive characterization and pre-breeding of crop wild relatives

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Researching Soils, Crops and Water in Zambia

Why do we need diverse characterization methods?

- Characterization and evaluation (C&E) data are required for proper management and use of plant genetic resources (PGR)
- Traditional C&E methods have not been producing sufficient data for *ex situ* conserved accessions
- *In situ* and on farm conservation activities do not usually generate C&E data for CWR populations growing in their natural environments and landraces managed by farmers
- Additional methods for characterization of populations, accessions, collections and conservation sites are required to enhance the management and utilization of PGR *in situ* and *ex situ*
- Some novel approaches:
  - genomics, transcriptomics, metabolomics, high-throughput phenotyping;
  - less resource intensive: **predictive characterization techniques**

Wild beet

Wild barley

Wild asparagus

What is predictive characterization?

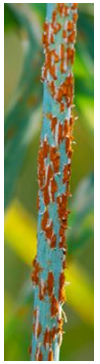
- Set of approaches that use geographic and environmental data along with Geographic Information Systems (GIS) analysis
- Hypothesis: different environments exert divergent selective pressures on plant populations and thus spatial genetic differentiation, developing adaptive traits specific to certain environments
- 'Predictive' in the sense that it assigns a probability of trait presence to uncharacterized germplasm (either *ex situ* or *in situ*) using
  - matching of specific biotic and abiotic characteristics associated with a collecting site
  - range of ecogeographical and climate information associated with sites
  - previously recorded C&E data for trait of interest in PGR collected from known sites
- Can be used with genebank collections, landraces managed on farm, populations of wild species

First applications: *ex situ* collections using FIGS

- FIGS = Focused Identification of Germplasm Strategy
- developed by ICARDA (International Center for Agricultural Research in Dry Areas) based on early work by Michael Mackay in the 1980s and 1990s (Mackay 1986, 1990, 1995)
- Based on expert knowledge, criteria were identified to describe environmental profiles where a resistance trait, e.g. to a specific pest, could have developed (biotic matching method)
- Example: Sunn pest – wheat
  - Areas of recent introduction of the pest were excluded
  - Areas that are too dry for the pest to thrive were excluded (less than 280 mm precipitation per year),
  - Areas with too low winter temperatures (below 10°C) were excluded
- Environmental profiles developed based on expert knowledge were used as filters when selecting uncharacterized accessions for field trials, to increase the likelihood of finding trait of interest in those accessions
- Later, environmental profiles were also modeled based on C&E data from already characterized samples as predictors (calibration method)

Examples of predictive association studies and identification of resistant material through the use of FIGS

- Predictive association between trait data and ecogeographic data for Nordic **barley** landraces
- Predictive association between biotic stress traits and ecogeographic data for **wheat** and **barley**
- Ug99 **wheat** rust:
  - Traditional characterization: 4563 wheat LR screened for Ug99 in Yemen 2007 ➔ 10.2 % resistant accessions
  - FIGS predictive characterization: 500 accessions selected from 3728 accession ➔ 25.8% resistant accessions



- Net blotch - **barley**
- Boron toxicity - **wheat**
- Sunn pest - **wheat**
- Powdery mildew - **wheat**
- Russian **wheat** aphid
- Drought – **faba bean**

Bari et al 2012, El Bouhssini et al 2011; Endresen 2010; Endresen et al 2011, 2012; Khazaei et al 2013; Mackay and Street 2004; Street et al 2008

Predictive characterization of CWR

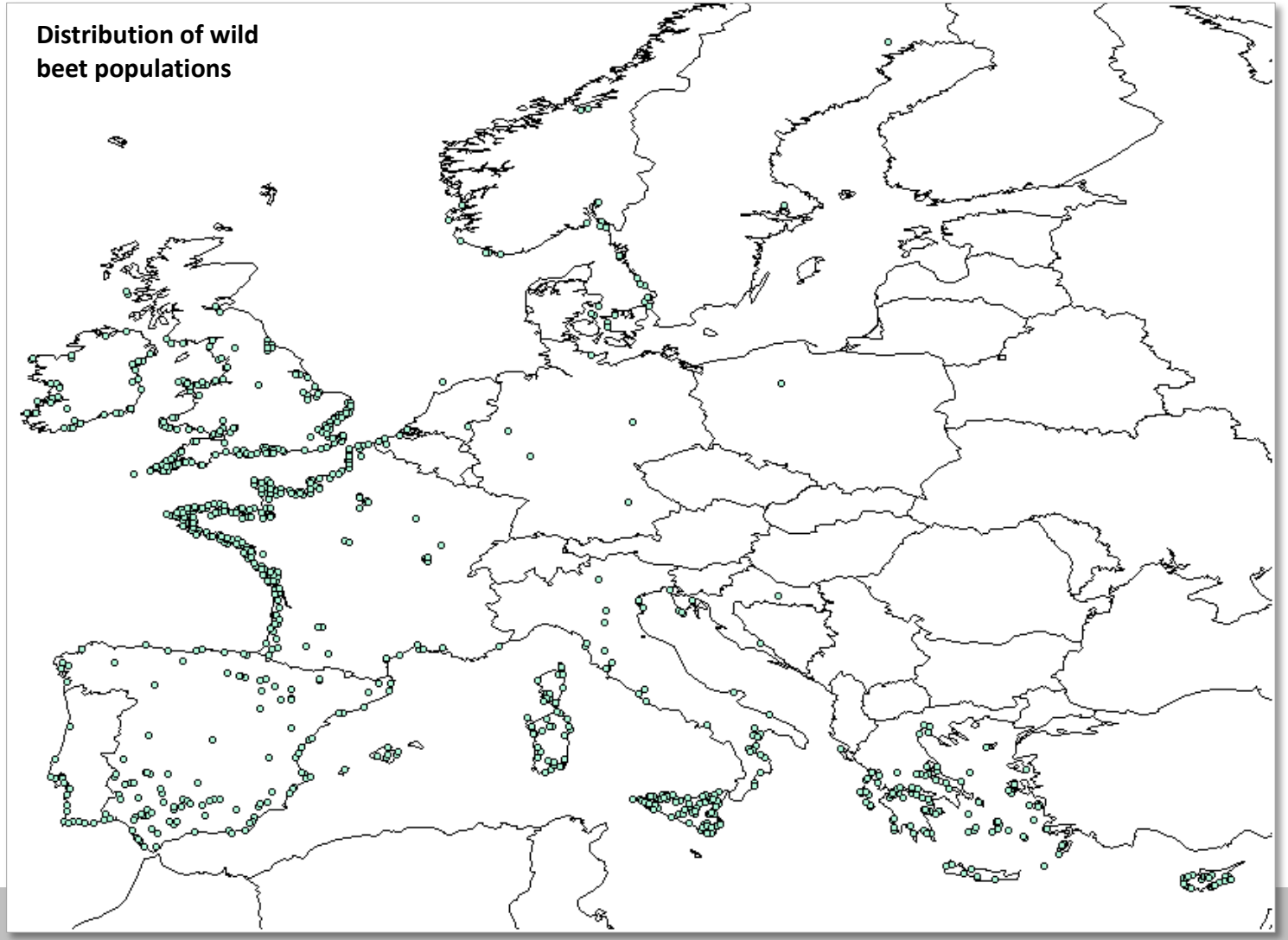
FIGS methods were adapted to optimize the search for populations and accessions with targeted adaptive abiotic traits in CWR

➔Ecogeographical filtering method

- Combines the spatial distribution of the target taxon on an ecogeographical land characterization map (ELC) with the ecogeographical characterization of those environments that are likely to impose selection pressure for the adaptive trait investigated to filter occurrence records
- Most adapted method for CWR given the lack of C&E data

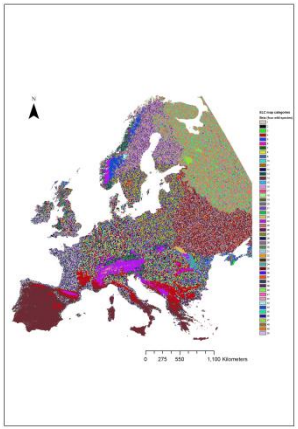
An example for ecogeographical filtering

Where to start looking for drought tolerant wild beet without characterizing 3000 samples?



Predictive characterization

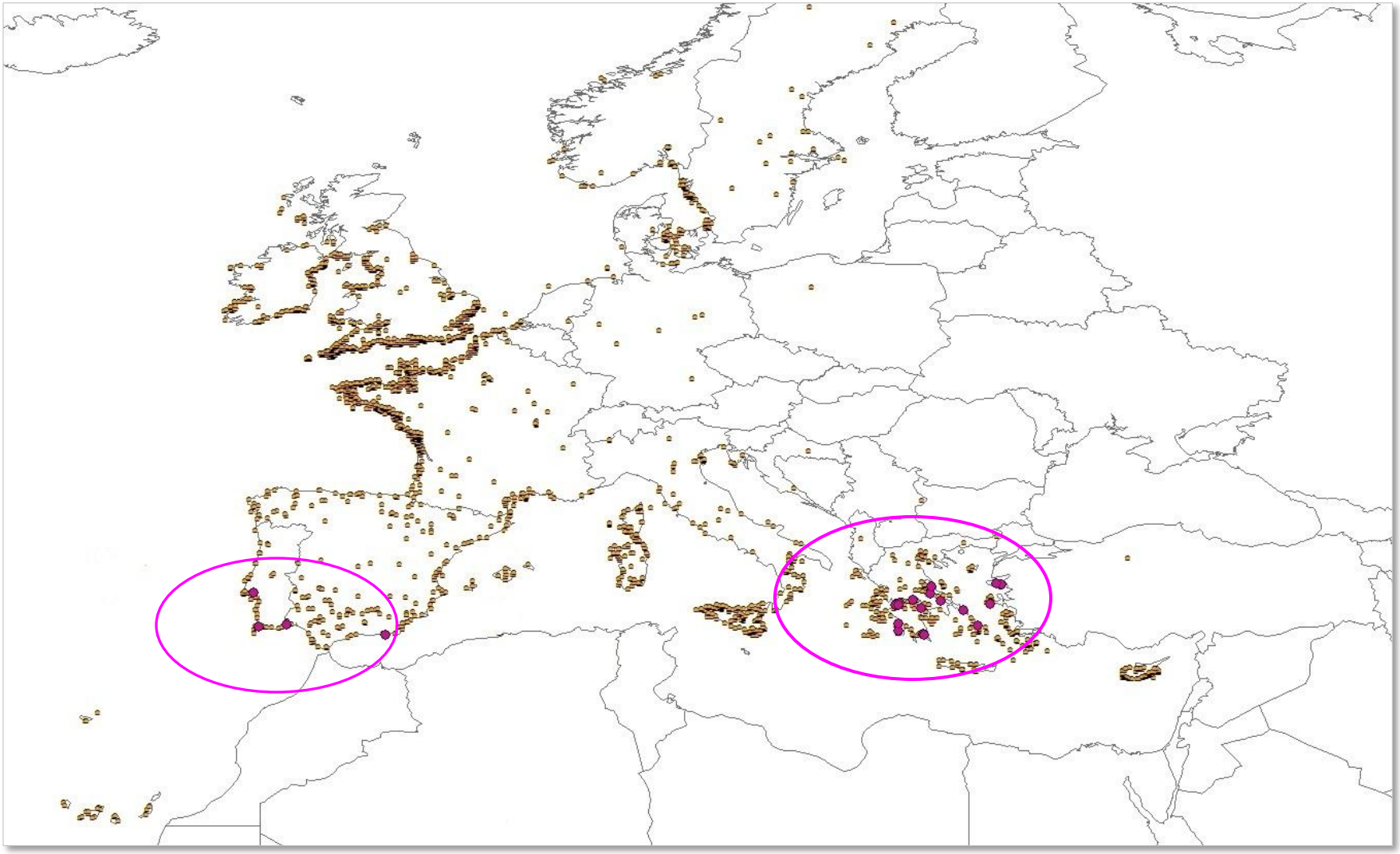
Location and environmental data

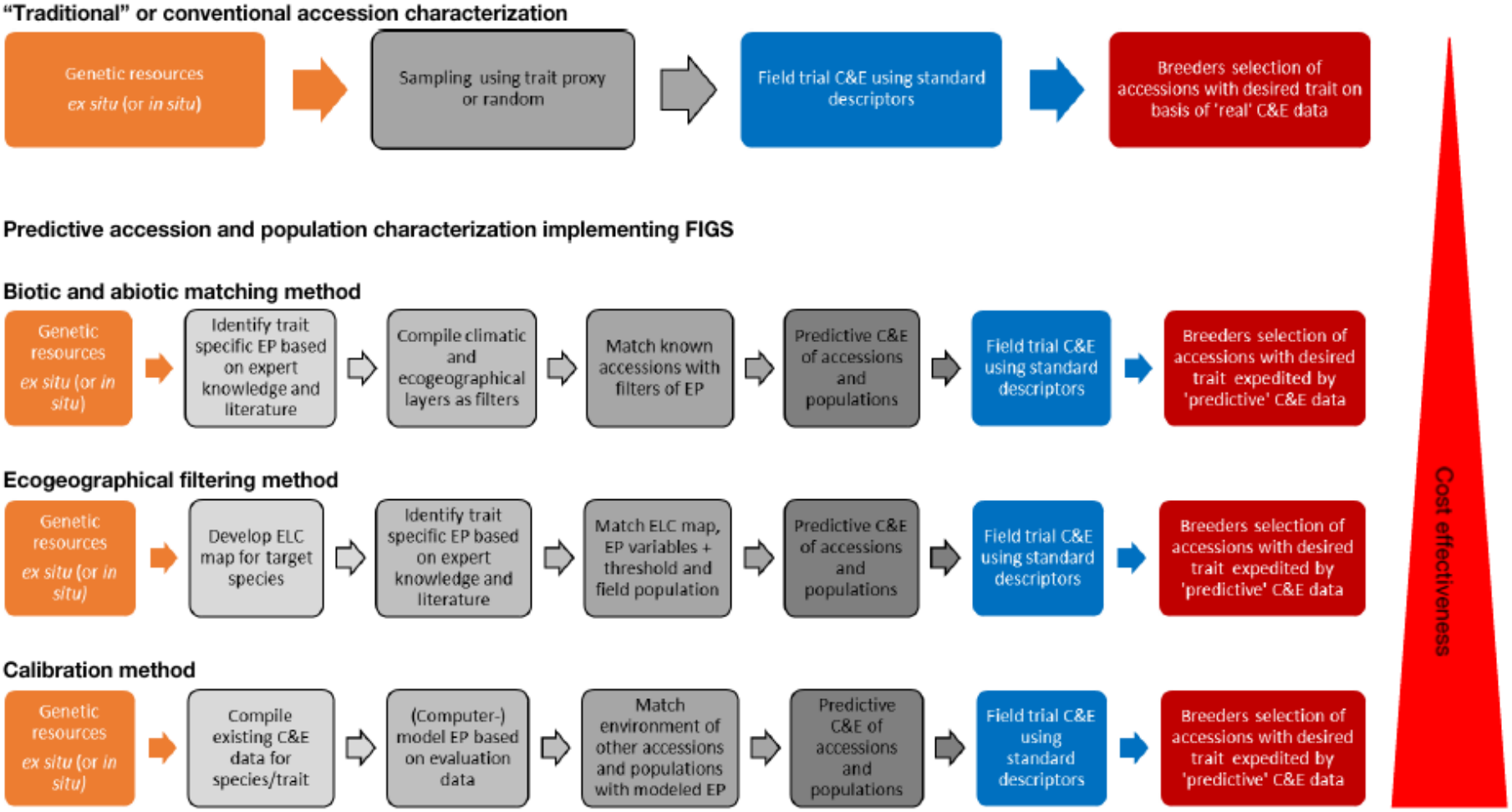


Statistics tool ‘R’

Small set of populations (FIGS set)

Result of predictive characterization



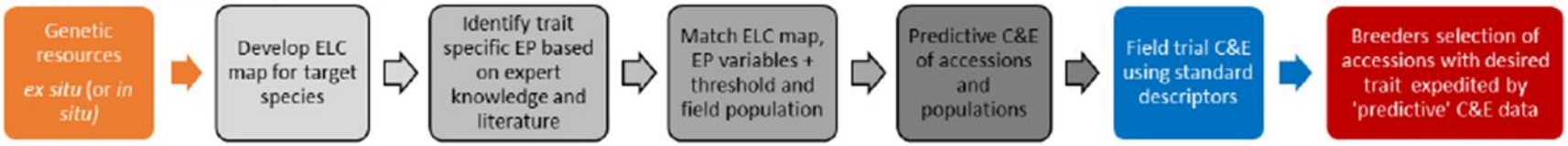


Key: C&E = Characterization and Evaluation; EP = Environmental Profile; ELC = Ecogeographical Land Characterization; FIGS = Focused Identification of Germplasm Strategy

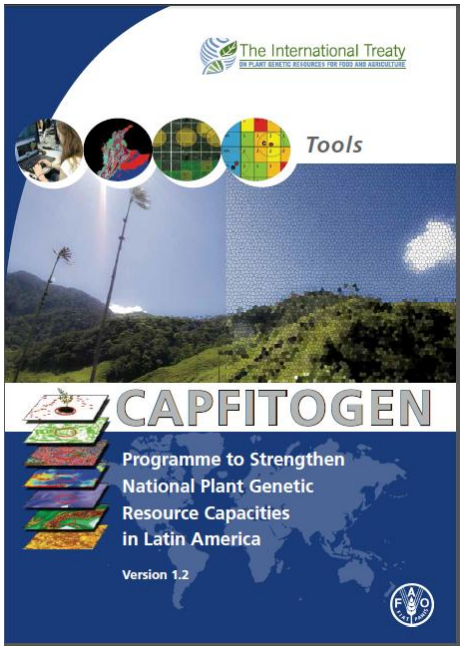
(Thormann *et al.* 2014)

Predictive characterization of CWR and CAPFITOGEN tools

Ecogeographical filtering method



Steps	CAPFITOGEN tools
Compile, clean and quality-check occurrence data	GEOQUAL
Develop ecogeographical land characterization map	ELCmapas
Environmental profile description for target trait and determination of threshold variables	FIGS_R
Analysis in R to identify set of accessions	FIGS_R



Thank you

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