

Conservation and Utilization of PGR at ICARDA

Study Case of *Lathyrus* species

Ali Shehadeh
Genetic Resources Section

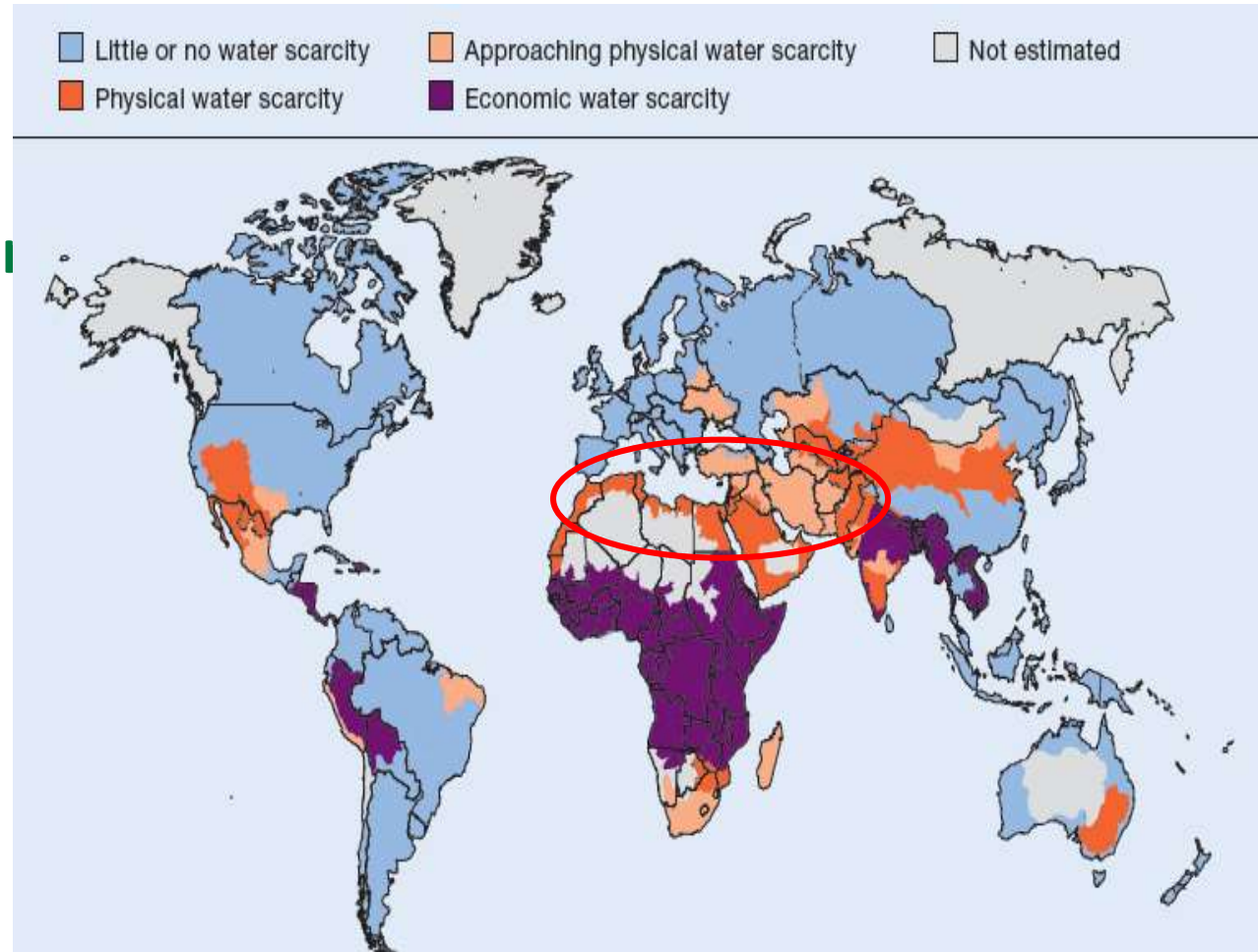
Bucharest, 10 April, 2019



The Challenges Facing Sustainable Agricultural Development in Dry Areas

Dry Areas: Fragile Dry Eco-Systems

- Physical water scarcity
- Rapid natural resource degradation and desertification
- Groundwater depletion
- Drought
- Salinity
- Climate change



Challenges to Enhancing Food Security in Dry Areas: Biotic Stresses

Fungi Diseases



Insect Pests



Weeds/Parasitic Weeds



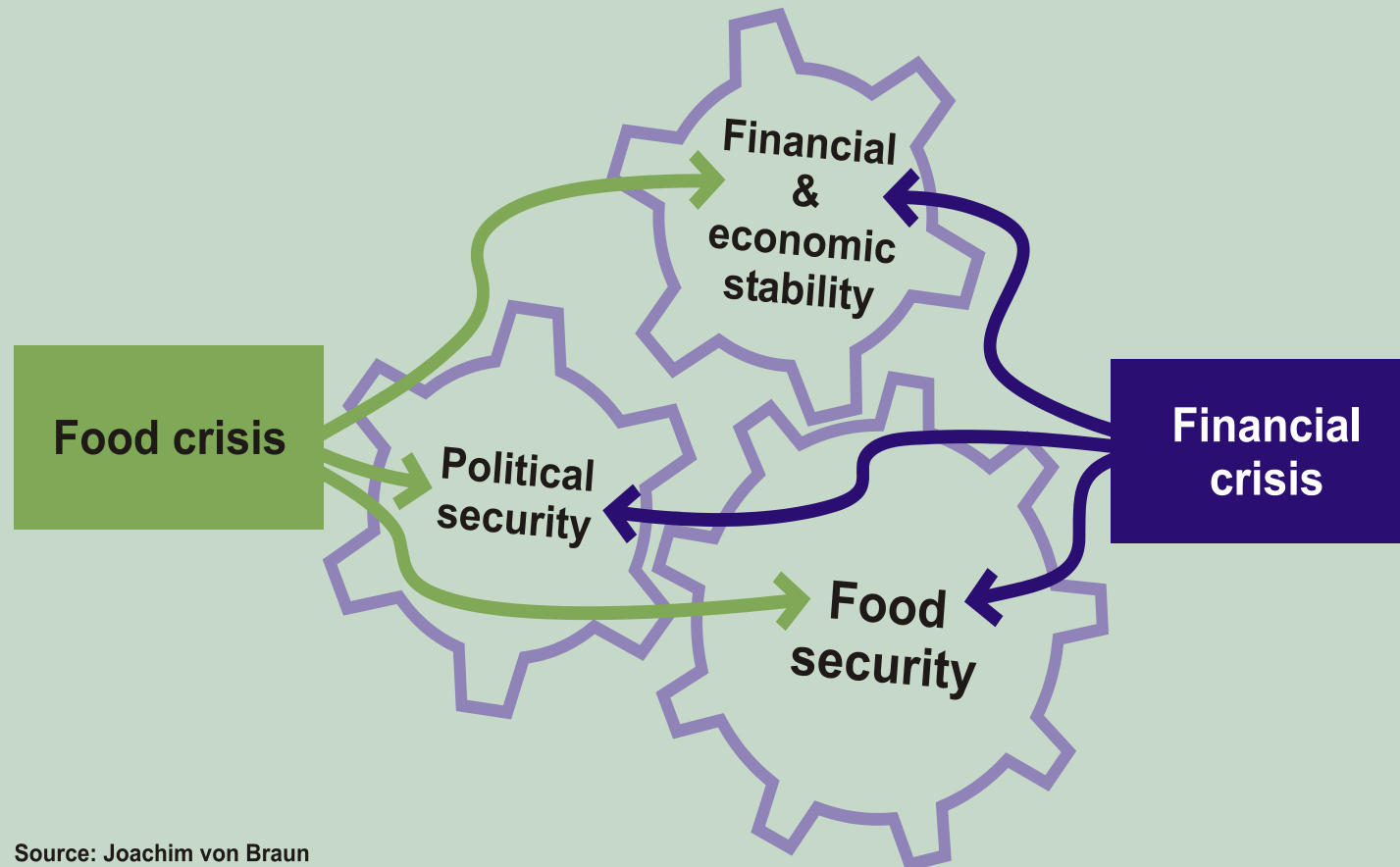
Further Challenges in the Drylands: Inadequate Policies and Insufficient Institutions

- **Inadequate agricultural policies for sustainable agricultural development**
- **Insufficient investment in agricultural research and development**



Politically volatile region: Importance of economic and political stability

Linkages between the food and financial crisis





ICARDA Vision, Mission and Mandate

ICARDA's Vision & Mission

Vision: Improved livelihoods of the resource-poor in dry areas

Mission: To contribute to the improvement of livelihoods of the resource poor in dry areas by enhancing food security and reducing poverty through research and partnerships to achieve sustainable increases in agricultural productivity and income, while ensuring the Efficient and more equitable use and conservation of natural resources.



Research mandate: Cereal improvement

Global Mandate



Regional Mandate



Research mandate: Food legume improvement

Global Mandate



Research Mandate

Natural resource management in non-tropical dry areas

Water use efficiency



Combating land degradation



Range improvement

Small ruminant nutrition

Forage Legumes



ICARDA's Research Programs

**Biodiversity and Crop
Genetic Improvement**

**Integrated Water and
Land Management**

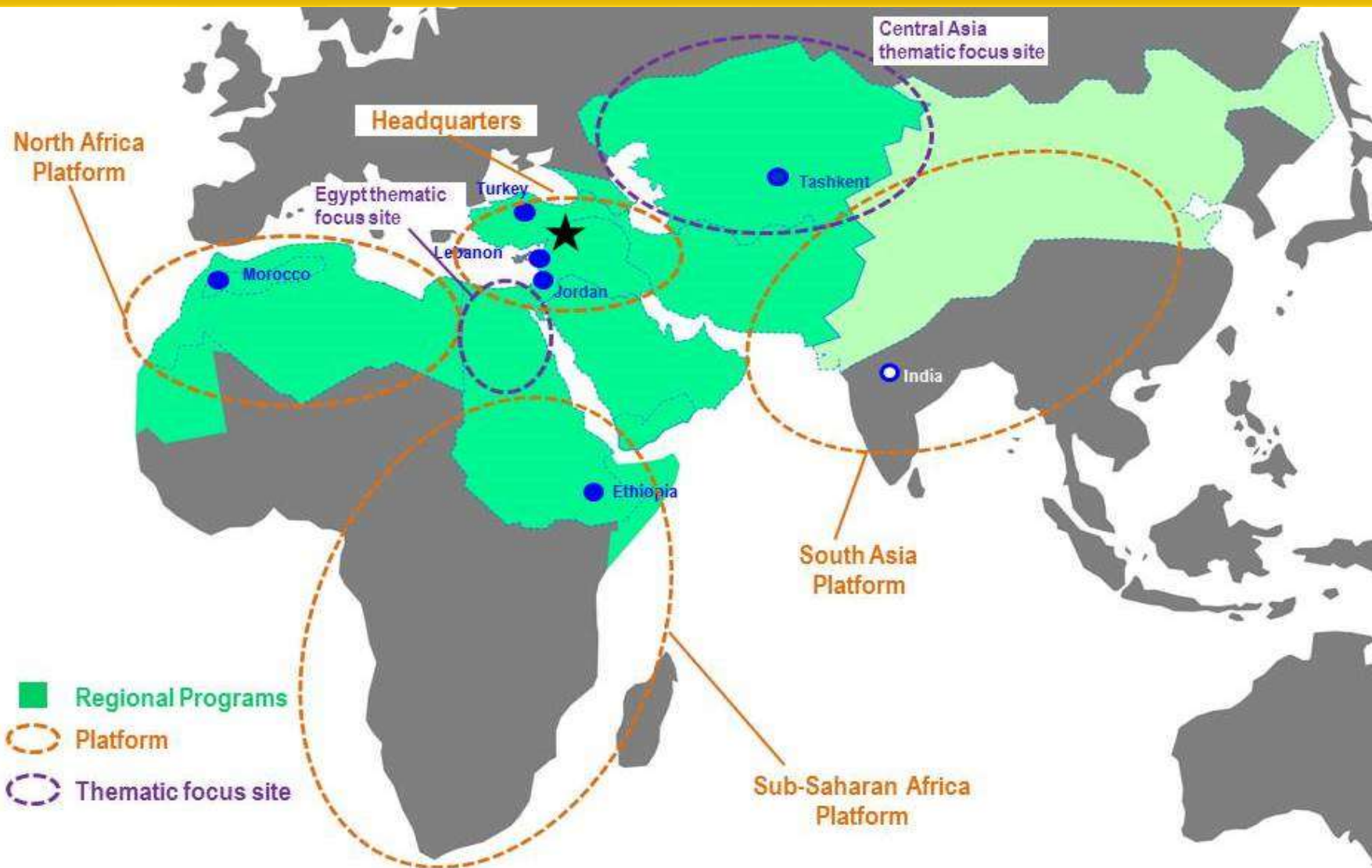
**Sustainable
Intensification &
Diversification of
Production Systems**

**Social, Economic and
Policy Research**

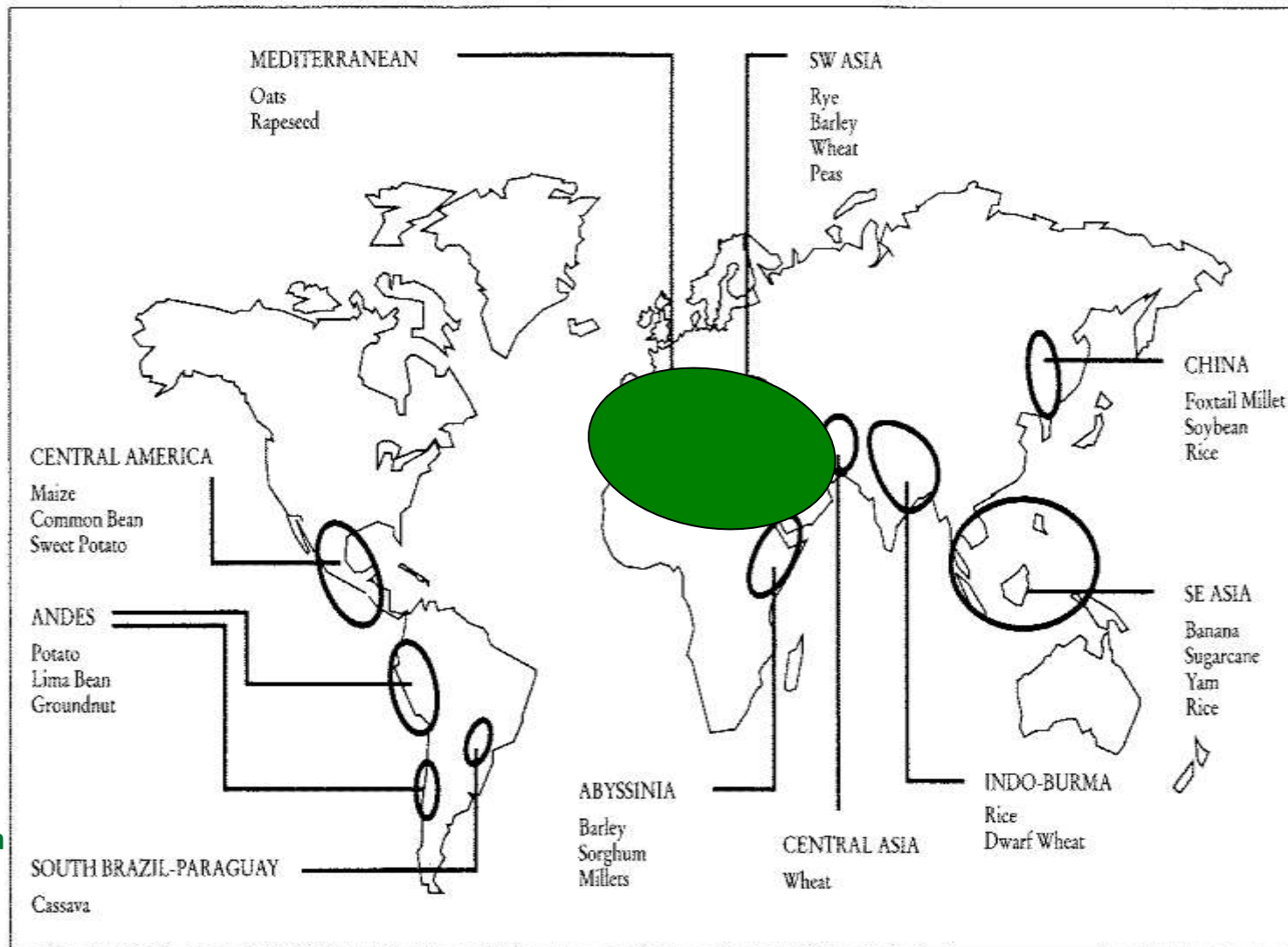
ICARDA's geographic mandate



Location of Platforms and Thematic Research sites



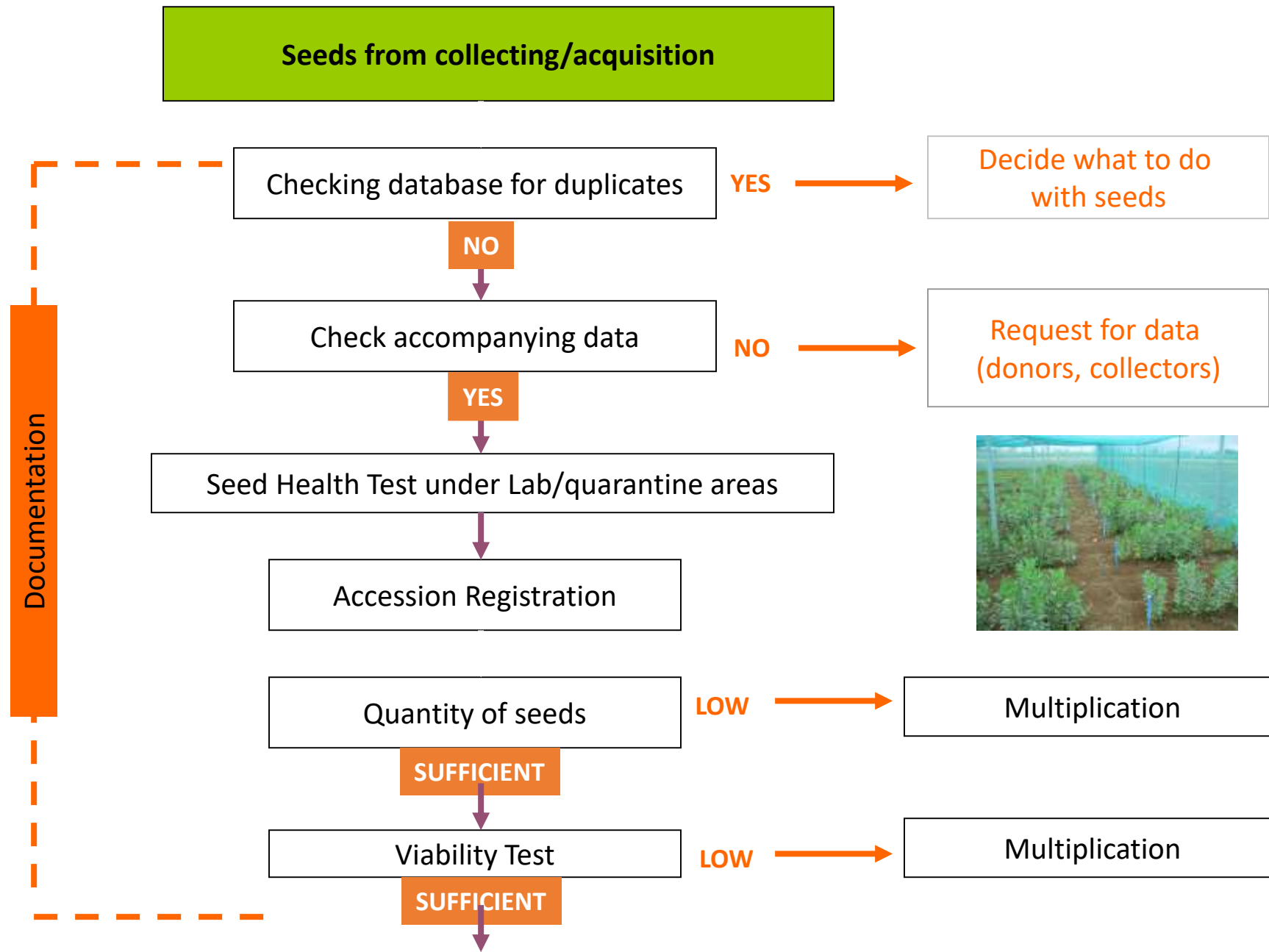
Middle East and North Africa region encompasses four major centers of diversity and the Mediterranean hot spots of endemic flora



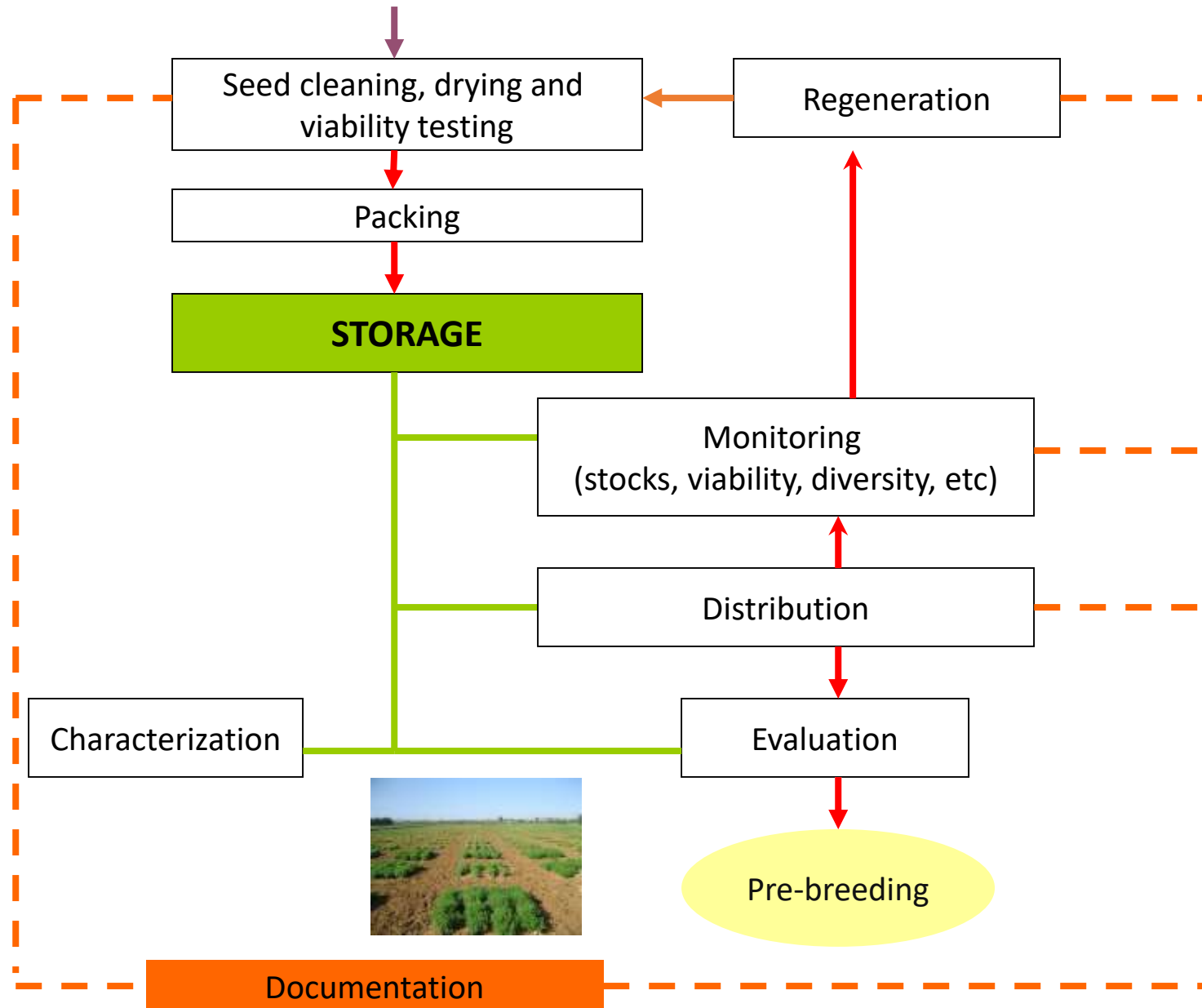
Proposed Model of Plant Genetic Conservation (Maxted *et al.*, 1997a).



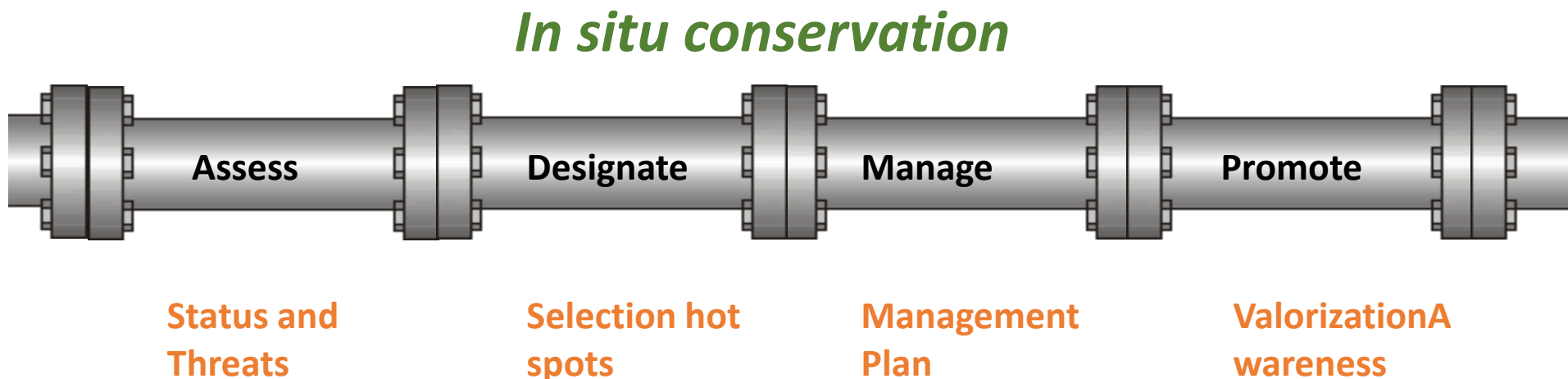
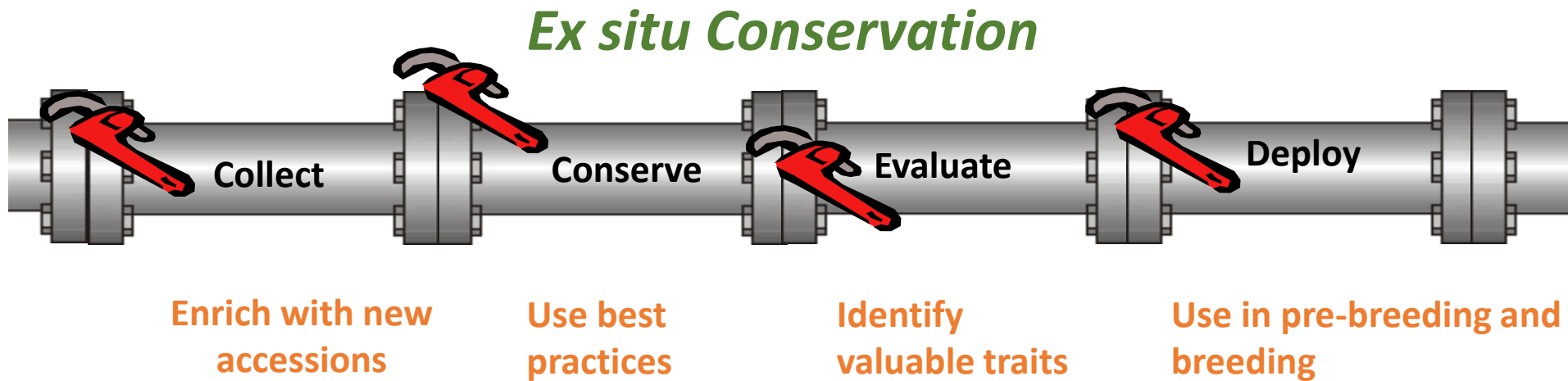
General sequence of operations in the Genebank



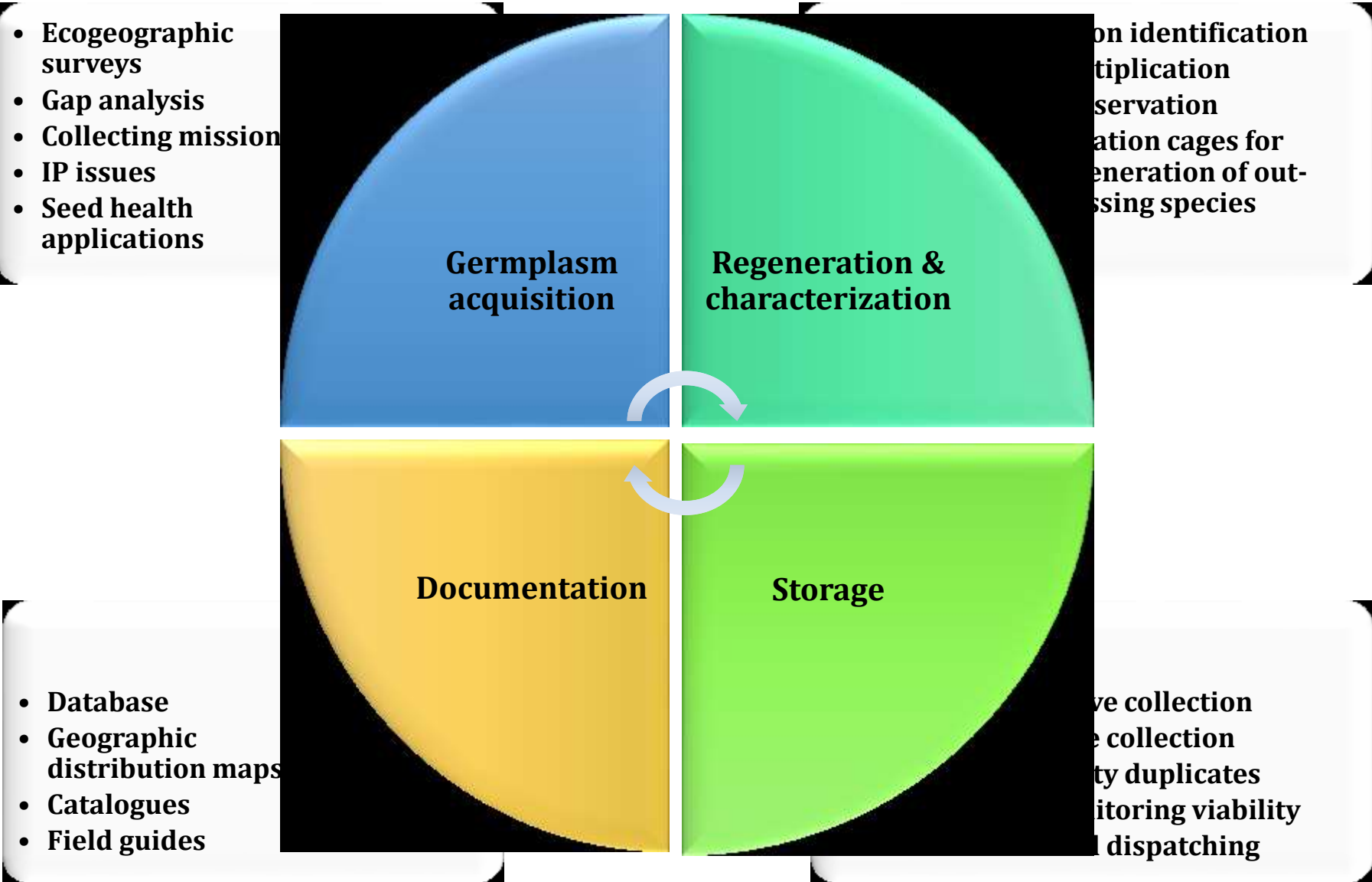
General sequence of operations in the Genebank (cont'd)



Genetic resources: Continuum conservation to utilization



Genetic resources conservation



ICARDA Gene Bank Holdings in three different locations



Crop/Wild Relatives	No. of Accessions	Crop/Wild Relatives	No. of Accc.
Faba bean BPL	3268	<i>Pisum</i>	6132
<i>Aegilops</i>	5157	<i>Trifolium</i>	5900
Barley	30215	<i>Vicia</i>	6561
Bread wheat	15090	Faba bean	6766
Durum wheat	20516	Chickpea	15195
Primitive wheat	1276	Lentil	13978
Wild <i>Hordeum</i>	2575	Wild <i>Cicer</i>	554
Wild <i>Triticum</i>	1833	Wild <i>Lens</i>	619
<i>Lathyrus</i>	4451	Range & pasture	7416
<i>Medicago</i> annual	9133	Others	244
Total			156879

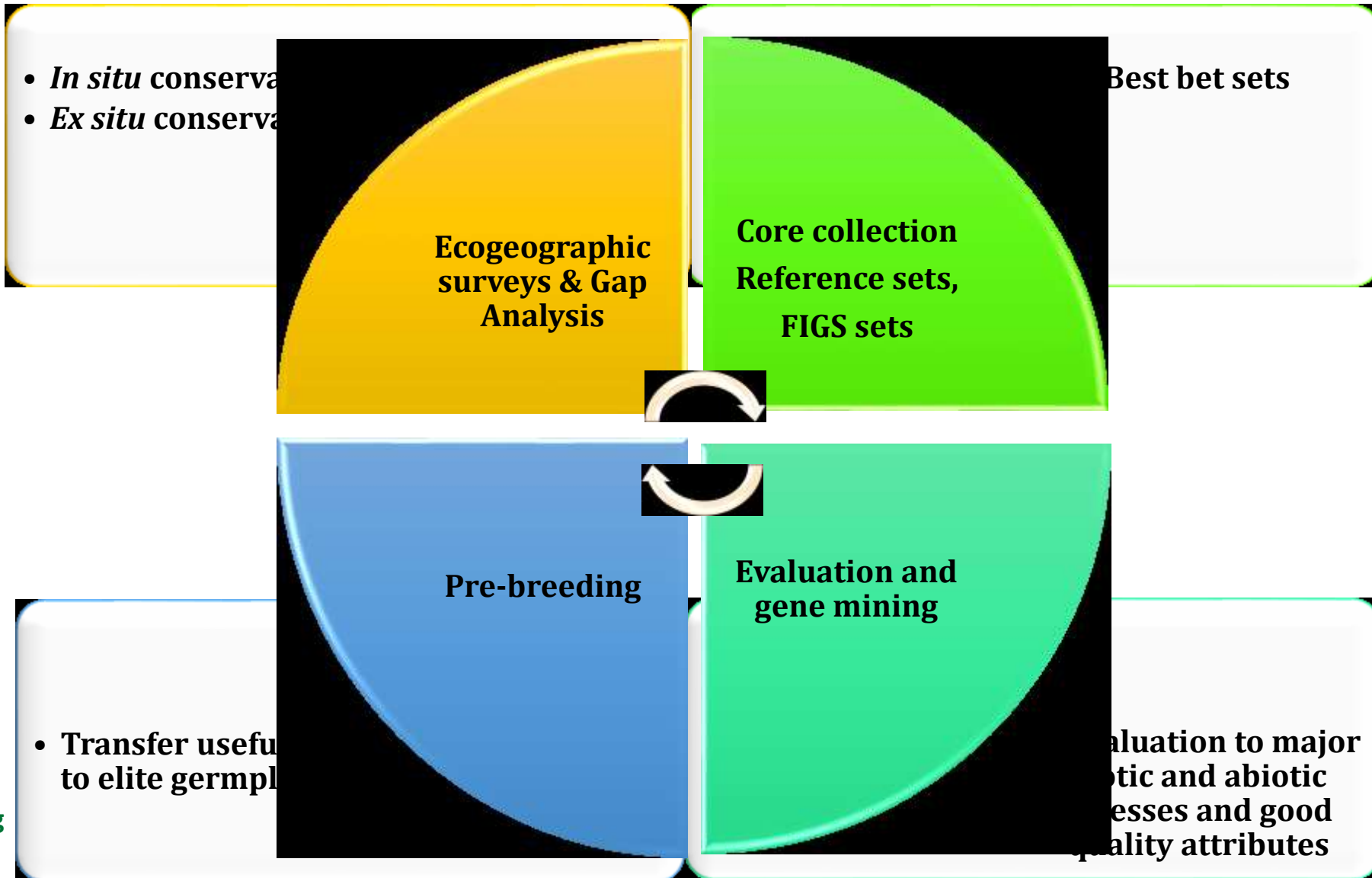


Mostly landraces and unique set of wild relatives

Geo-referencing data for ICARDA's holdings



Genetic resources utilization



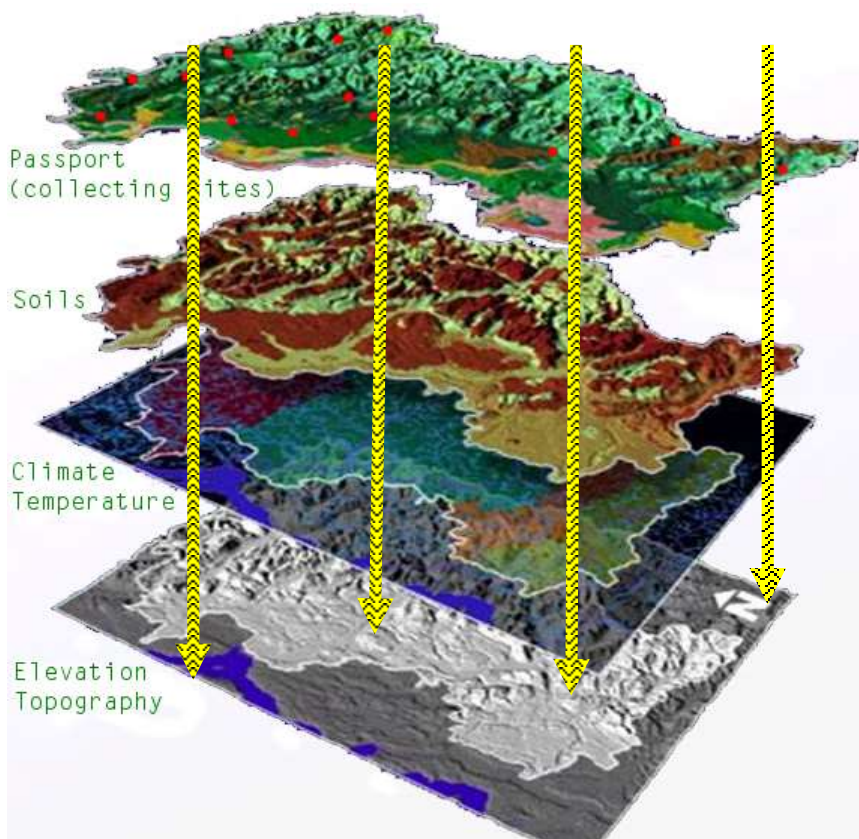
Core collections

“A limited set of accessions representing, with a minimum of repetitiveness, the genetic diversity of a crop species and its wild relatives”. Frankel, 1984

1. Sampling of a constant number of accessions per region (C strategy),
2. Sampling in proportion to the logarithm of the number of accessions available per region (L strategy),
3. Marker-assisted strategy (M strategy) where the sampling is based on marker allele richness.

Passport data of accessions to be used to develop groups based on the geographical origin of the accessions and the sampling is to carry out randomly within these groups. The clustering methods include molecular and morphological to guide the sampling (Schoen and Brown, 1993).

Focused identification of Germplasm Strategy (FIGS)



A rational approach to exploiting large genetic resource collections

Efficient and effective methods to mine genebanks for useful traits to breeders

Deliver priority trait best bet subsets to requestors

Quantification of trait-environment relationship



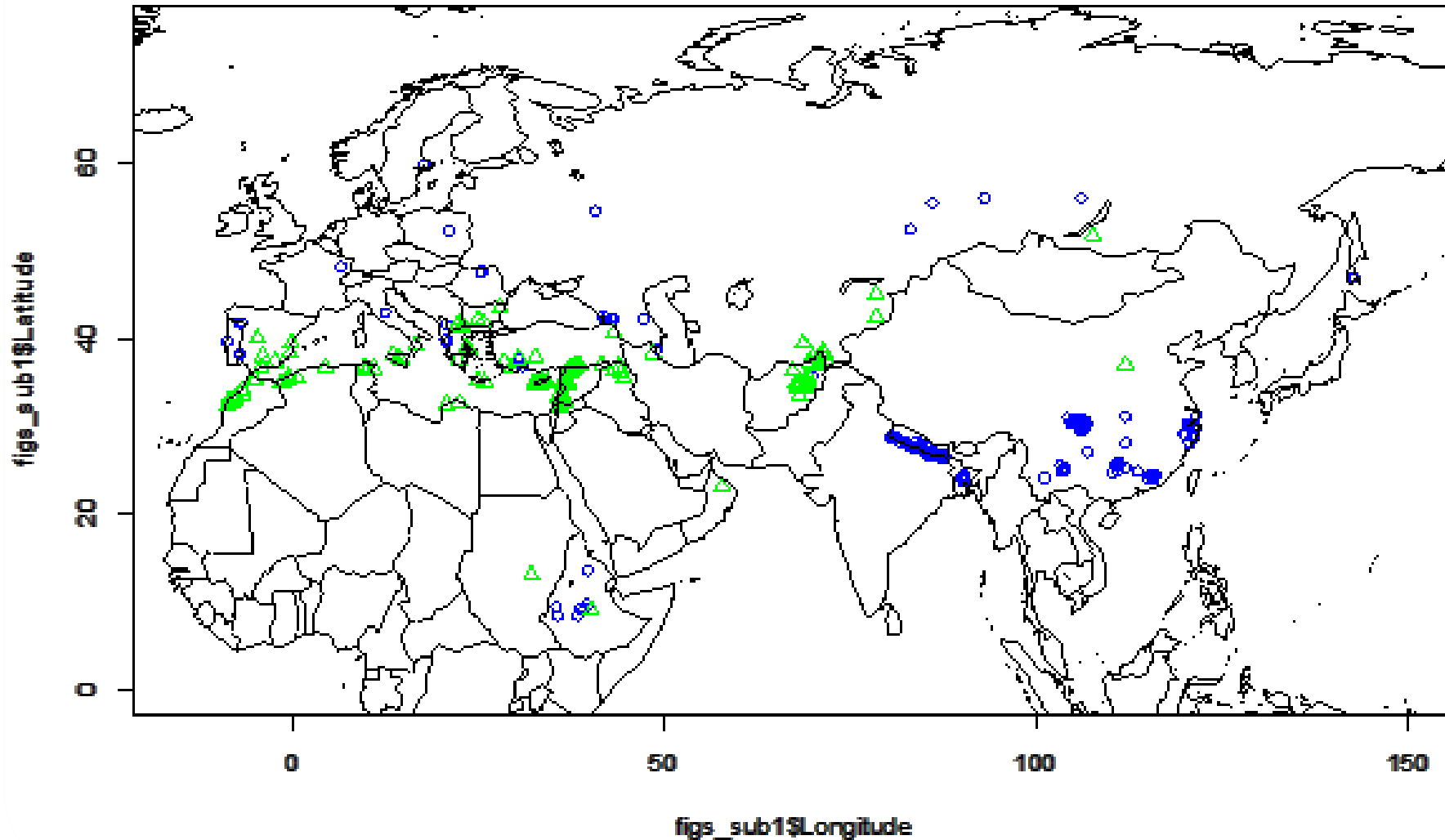
A priori information



Develop trait subsets



Evaluation and refining algorithms



Characterization/Evaluation

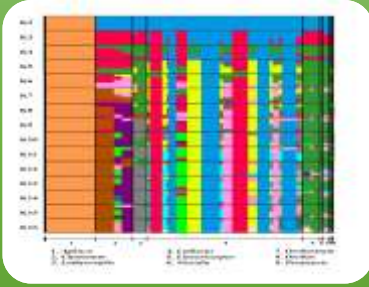


Characterization/preliminary evaluation using international set of descriptors

- In the field
- In the plastic house
- Isolation cages for cross-pollinating species





In-depth evaluation in collaboration with Germplasm Program



Molecular characterization

Crop Genebank Knowledge Base

English Español

Crop Genebank Knowledge Base  Strengthening capacity to manage genebanks 

[Home](#) [Crops](#) [Procedures](#) [Management strategies](#) [Learning resources](#)

Crops ▶ Forage legumes

- ▶ Banana
- ▶ Barley
- ▶ Cassava
- ▶ Chickpea
- ▶ Forage grasses
- ▶ **Forage legumes**
 - ▶ Conservation
 - ▶ Characterization
 - ▶ Regeneration
 - ▶ Safety duplication
- ▶ Maize
- ▶ Radish
- ▶ Rice
- ▶ Wheat
- ▶ Other crops (Regeneration guidelines)


Forage legume genetic resources

Contact person for Forage legume: [Jean Hanson, ILRI, Ethiopia](#)

Contributors to the section on best practices for management of forage legume genetic resources: ILRI, Ethiopia (Jean Hanson, Juvy B. Cantrell, Janice Proud); ICARDA, Syria (Ahmed Amri, Kenneth Street, Ali Shehadeh, Natalya Rukhkyan, Siham Asaad); GRCTPL, Australia (Richard Snowball); Bioversity International/ILRI, Addis Ababa, Ethiopia (Alexandra Jorge); CIAT, Cali, Colombia (Daniel Debouk, Maritza Cuervo).
External reviewer: Mak van de Wouw (Centre for Genetic Resources, The Netherlands)

Compilation of best practices

Information on genebank management of forage legumes was gathered from current genebank practices, accumulated experience, literature and the websites of major forage genebanks ([CIAT](#), [ICARDA](#), [ILRI](#), [CSIRO-Australia](#), [IGER-UK](#), [USDA-Fort Collins](#), [EMBRAPA-Brazil](#)) and compiled into tables of procedures. This provided the basic information for selection, justification and recommendations that were then compiled, distinguishing information for seed banks and field banks. This information was finally uploaded into this website, complemented with relevant photos and revised and validated by the crop experts.



An example of a forage legume (*Ononis sicula*) (photo: ICARDA)

Importance and origin

Over 1500 species of legumes (from about a total of 17 000 legume species worldwide) can be used as feed for livestock, although only about 60 species have been developed and widely used as cultivated forages. The use of forage legumes is estimated to be as old as 11 000 years, with some species first being used as grain for human consumption and more recently only used for fodder or pasture, or vice versa (Mathison, 1983). Although tropical forage legumes have been grazed in natural habitats for many years, they have only been under cultivation for as little as 75 years, while some like *Centrosema pubescens*, *Labiab purpureus* and *Pueraria javanica* were used as cover crops and green manure at least a century earlier. Tropical legumes may have originated from tropical forests and natural grasslands and were later adapted to a variety of environments. Currently grasslands can be found from the tropics to the Arctic regions, from high rainfall regions to deserts and from rocky slopes and sand dunes to swamps (Williams, 1983).

Conservation field guide to Grasspeas

Lathyrus Identification Key



L. sativus L., Sp. 730 (1753). Ic: Jav. & Csap., Ic. Fl. Hung. t. 2U (1932); Villax, Cult. Pl. Fourr. Medit. Occid. t. 143 (1963).

Synonyms - *Lathyrus asiaticus* (Zalkind) Kudr., *Lathyrus sativas* L., *Lathyrus sativus* L. subsp. *asiaticus* Zalkind

Description - Annual, slender, ascending plant. Vegetative parts glabrous when green. Plants 10–70(–100) cm. Stems winged. Leaflets present, 1 pair per leaf, pinnate. Leaf rachis not laminate, tendrillous. Leaflets linear, or lanceolate, apex mucronate, 20–100 mm long, 1.5–11 mm wide, venation parallel. Stipules lanceolate, or lanceolate-accumbinate, base semi-sagittate, margin entire, glabrous, 1–1.5 times as broad as stem. Stipules shorter than petiole. Peduncles 1–40(–45) mm long, longer than leaf. Pedicel 5–8 mm long. Flowers 1 per inflorescence, concolorous. Corolla white, or violet, or blue. Flower 14–20 mm long. Standard with more than 5 conspicuous veins, apex strongly emarginate. Wings white, or blue, or violet. Calyx glabrous, 7–10 mm long, tube not gibbous, teeth unequal, straight, longer than tube. Calyx lower teeth longer than tube. Style 5–6 mm, twisted, linear. Ovary oblong. Legume beaked, broadly-oblong. Legume 9–12 mm long, 6–8 mm wide, glabrous. Lower suture not ciliate. Mature legume indehiscent. Amphicarpic pods not present. Legume valves glabrous, eglandular. Upper suture broadly winged. Seed surface smooth. Seeds per pod (2–)3–4(–5). Hilum 1.5 mm long.

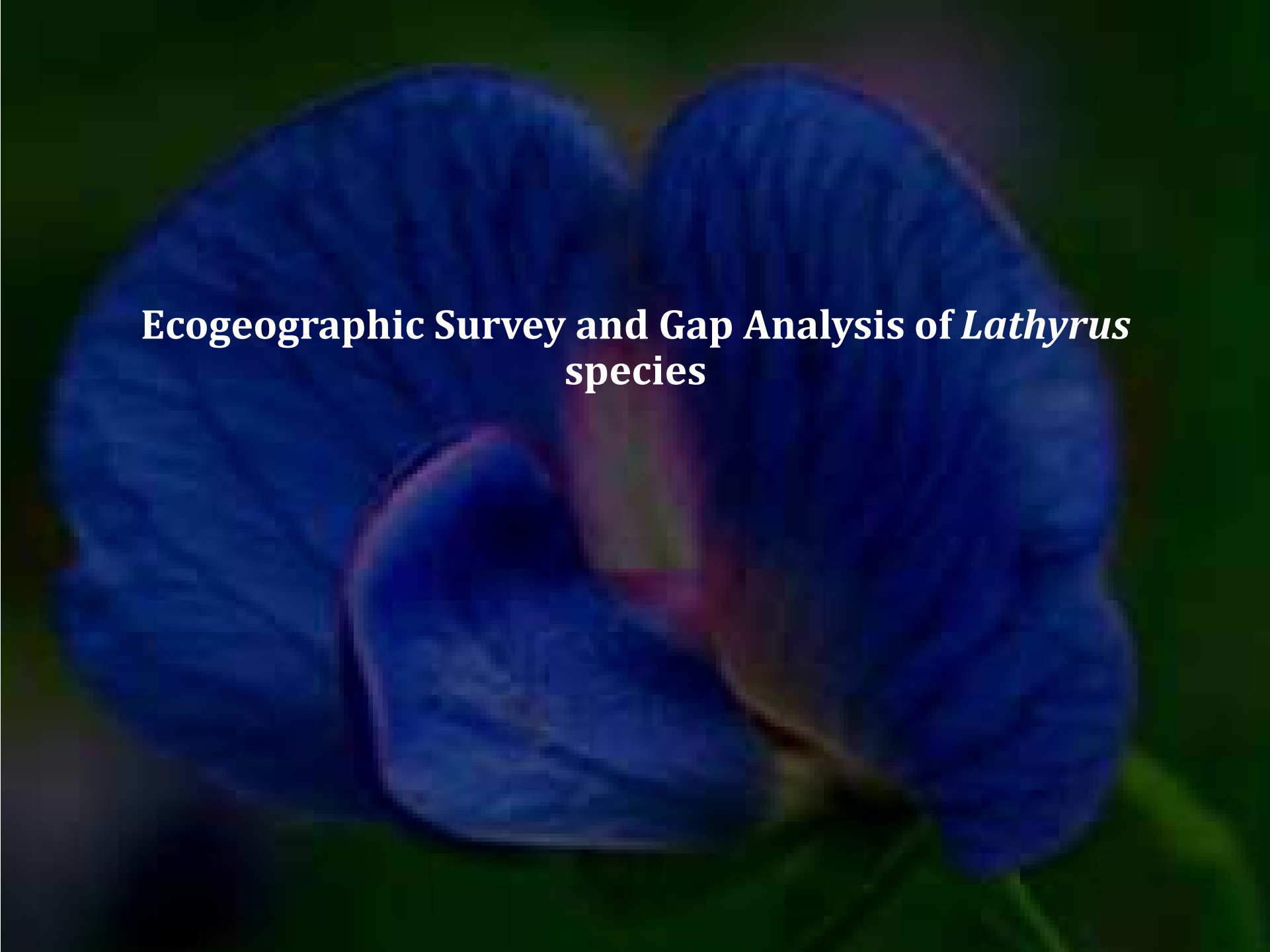
Habitat - Field crop and weed, s.l.-1520 m.


- Geographical distribution - Native:**
- **AFRICA**
East Tropical Africa: Tanzania
 - *Eastern Asia:* Indonesia- Java
- Uncertain Origin:**
- **ASIA-TEMPERATE**
Western Asia: Afghanistan, Iran; Iraq; Palestine; Jordan; Lebanon; Syria






Ecogeographic Survey and Gap Analysis of *Lathyrus* species




- 
- National, regional and international efforts are ongoing for collecting and conserving *ex situ* the genetic resources, new approaches are needed to fill the gaps in the existing collections (Amri *et al.*, 2008, unpublished report). There has been relatively little effort in conserving *in situ*/on-farm the landraces and wild relatives of major crops as these were not targeted with most of the existing genetic reserve (Guarino *et al.*, 1995; Hawkes *et al.*, 2000, Amri *et al.*, 2008 unpublished report).
 - One such novel approach to help prioritize conservation action is genetic gap analysis.
 - Burley (1988) proposed four steps to identify the gaps in conservation efforts:
 - identifying and classifying biodiversity;
 - locating areas managed primarily for biodiversity;
 - identifying biodiversity that is under-represented in the managed areas; and
 - setting priorities for conservation action (Jennings, 2000).



The approach of conservation gap analysis proposed by Maxted *et al.* (2008) is based on comparing natural diversity with current conservation actions to identify the gaps to revise the conservation strategy. He recommended four steps for gap analysis:

- identification of priority taxa,
- identification of ecological breadth and complementary hotspots using distributional data,
- matching the identified ecogeographic breadth and complementary hotspots with the existing conservation actions, and
- ending with the formulation of a revised *in situ* and *ex situ* conservation strategy.

- 
- Gap analysis can also be applied to taxonomic and genetic diversity and its distribution in existing wild populations, as illustrated in the **“Ecogeographic Survey and Gap Analysis for Different Sections of *Lathyrus*”** L. Shehadeh et al., 2013.
 - The *Lathyrus* gene pool is an ideal candidate for this application of a gap analysis due to its adaptation to harsh environments and the agricultural importance of some species, such as grass pea as food and feed for poor people. A review of *ex situ* conservation efforts of *Lathyrus* was done through the *Lathyrus* conservation strategy undertaken in 2007 by the Global Crop Diversity Trust in collaboration with ICARDA (GCDT, 2007),

Importance of *Lathyrus* genus

Species	Use
<i>L. annuus</i>	Pulse, Fodder
<i>L. aphaca</i>	Fodder
<i>L. blepharicarpus</i>	Pulse
<i>L. cicera</i>	Pulse, Fodder
<i>L. clymenum</i>	Pulse
<i>L. gorgoni</i>	Fodder
<i>L. hirsutus</i>	Forage
<i>L. latifolius</i>	Horticulture
<i>L. ochrus</i>	Pulse, Fodder
<i>L. odoratus</i>	Horticulture
<i>L. pratensis</i>	Forage
<i>L. rotundifolius</i>	Horticulture
<i>L. sativus</i>	Pulse, Forage
<i>L. sylvestris</i>	Forage
<i>L. tingitanus</i>	Fodder
<i>L. tuberosus</i>	Tubers

- Useful crops and ornamental plants.
- About 160 species belonging 13 sections;
- Four main cultivated species: *L. sativus*, *L. cicera*, *L. odoratus* and *L. ochrus* included in sections *Lathyrus* and *Clymenum*.
- *Lathyrus* species, may play a key role in adapting to climate change;
- Improvement in yields and development of low or free ODAP varieties.

Methodology

- Taxonomic, ecological, geographic and conservation information for *Lathyrus* were collated;
 - Passport data associated with herbarium specimens,
 - Germplasm accessions data;
 - Secondary data from media sources.
- The *ex situ* conservation status of the genus was assessed to provide a priority ranking for future collection missions;
- Patterns of species richness were analyzed and *in situ* hotspots identified;
- Target IUCN-recognized protected areas are identified as potential sites to establish genetic reserves.

Ecogeographic survey

Taxonomic, ecological, geographic and conservation information for *Lathyrus* were collated from ICARDA, Global Biodiversity Information Facilities (GBIF) and herbarium specimens survey made during the project.

ICARDA GR database (network) - Lathyrus

Edit

Data for selection ALL (3338) - 1

Accession: 60012 Lathyrus arbuscula Origin country: SYR

IFLA: [] Site code: SYR77.200 Collector: Sawm/ICARDA

Mission code: SYR77 Site number: 200 Butt: SADAF

Country: SYR Crawford: SADAF

Province (Admin1): Latakia Admin2: Oibbons

Site: Latakia Site notes: []

Longitude: E35 47 27 Decline: 35 30 03 Dominant species: []

Latitude: N35 31 22 Decline: 35 52 28 Characteristic species: []

Altitude: 1 Precision: 9 Patenrock: []

AK_DEM: 47 Soil texture: []

Slope: [] Soil depth (cm): []

Aspect: [] Soil PH (code): [] Habitat: [] Area sampled: []

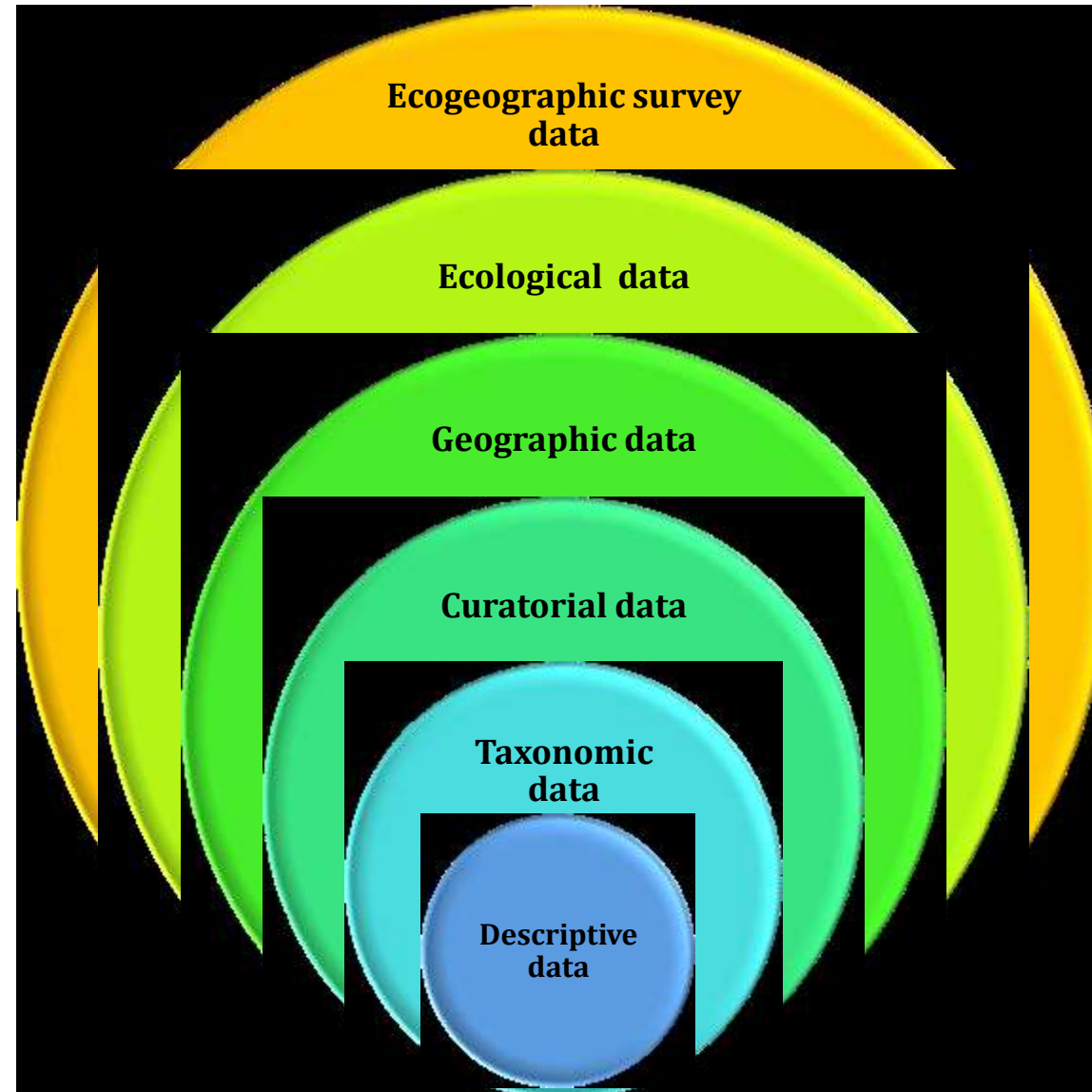
Rainfall: 875 Soil salinity (code): [] Site mgated/dry: [] Plants sampled: []

Water rel: [] HCL reaction (code): [] Threshed: []



GRS, ICARDA

Ecogeographic survey data



Data process

Standardization to a single format

Duplicate observations identified and removed

Occurrences identified outside of the natural range of the species were not considered in the final analysis

Unknown locations removed

Basic statistics describing the taxonomic, geographic, curatorial and ecological data were derived

Geo-reference data was checked

Each data field was indexed, and errors and invalid entries were manually corrected

Ecogeographic surveys datasets

A total of 157,959 records were gathered



61,081 unique herbarium and germplasm of
97 Lathyrus species were derived



18,147 unique herbarium and
germplasm accessions of 37 priority
species were used in this study

Gene pool concept of *Lathyrus*

**Primary gene pool
GP1**

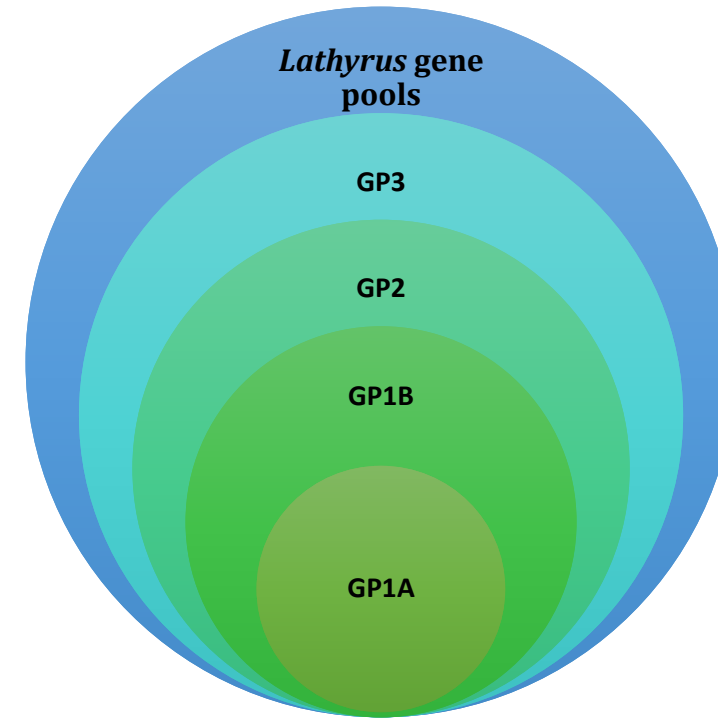
- GP1A (Cultivated forms of *L. sativus*)
- GP1B (Wild forms of *L. sativus*)

**Secondary gene pool
GP2**

- *L. chrysanthus*
- *L. gorgoni*
- *L. marmoratus*
- *L. pseudocicera*
- *L. amphicarpos*
- *L. blepharicarpus*
- *L. chloranthus*
- *L. cicera*
- *L. hierosolymitanus*
- *L. hirsutus*

**Tertiary gene pool
GP3**

- Other *Lathyrus* species



Gap analysis

Conservation gap analysis is based on comparing natural diversity with current conservation actions to identify the gaps to revise the conservation and utilization strategies



- Collecting to fill the gaps in the existing *ex situ* collections;
- New collecting missions (Targeted collections);
- *In situ* Conservation of crop wild relatives;
- On-farm conservation of the landraces of major crops.

Steps of gap analysis

Identification of priority taxa



Identification of ecological layer and complementary hotspots

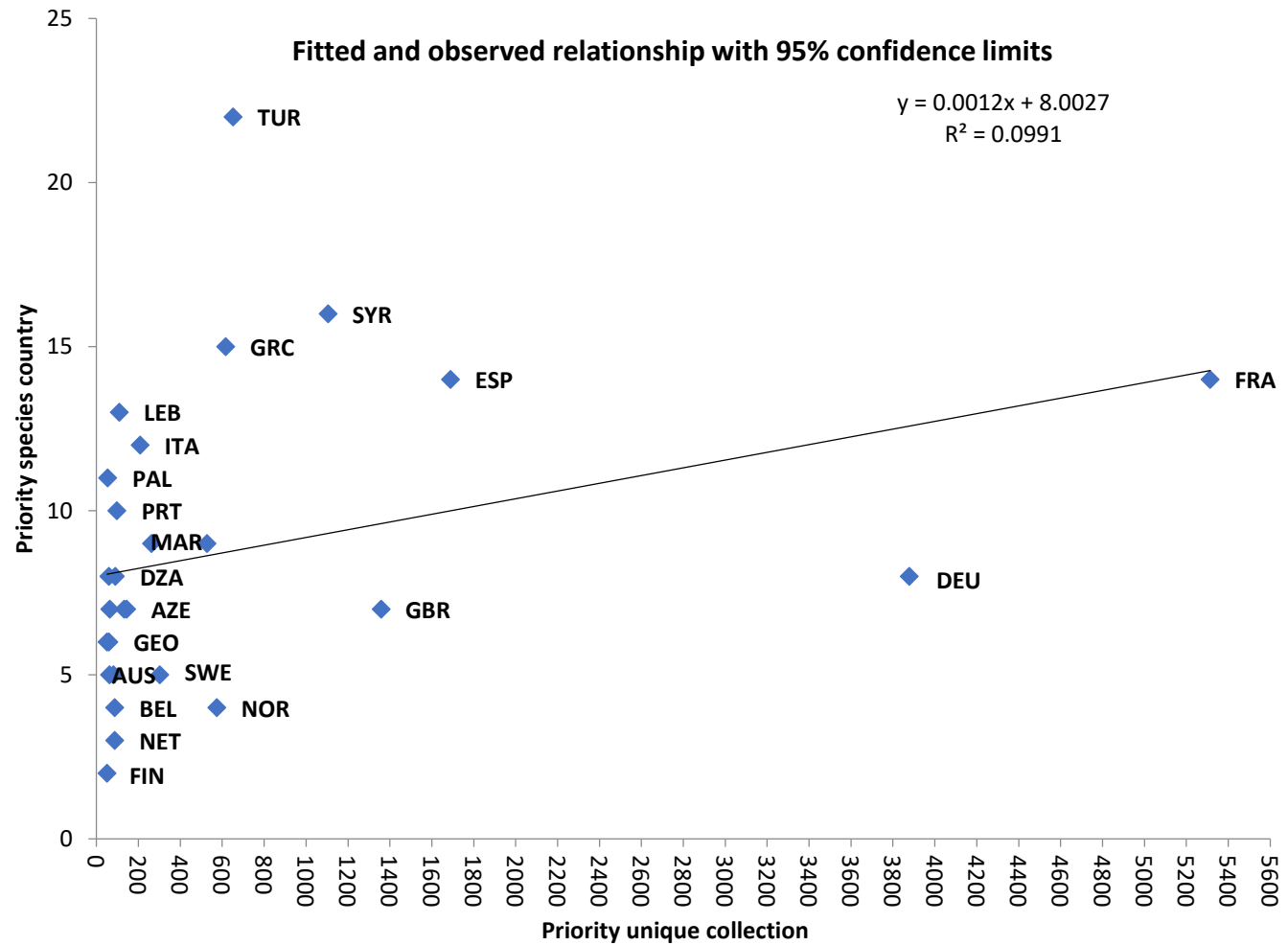


Matching the identified complementary hotspots with the existing conservation actions, and



Formulation of a revised *in situ* and *ex situ* conservation strategy

Regression of *Lathyrus* priority species against the number of records for each country.



AZE: Azerbaijan, AUT: Austria, BEL: Belgium, DEU: Germany, DZA: Algeria, ESP: Spain, FIN: Finland, FRA: France, GBR: Great Britain, GEO: Georgia, GRC: Greece, ITA: Italy, NET: Netherlands, NOR: Norway, LEB: Lebanon, MAR: Morocco, PAL: Palestine, PRT: Portugal, SWE: Sweden, SYR: Syria, TUR: Turkey.

Ex situ conservation priorities

Geo-referenced passport data associated for *Lathyrus* species used to identify gaps in current *ex situ* conservation

High priority: <100 accession *ex situ* conserved

Medium priority: >100<500 accessions

Low priority: > 500 accessions

Ecogeographic data set of the priority species included in the analysis

Species	Accessions in Global <i>Lathyrus</i> Database	Accessions in EURISCO	Accessions in USDA	Total germplasm accessions	Georeferenced accession & herbaria samples
<i>cicera</i>	214	558	42	814	1321
<i>ochrus</i>	160	185	25	370	486
<i>hirsutus</i>	29	129	21	179	1532
<i>hierosolymitanus</i>	129	7	4	140	444
<i>clymenum</i>	18	84	25	127	947
<i>tingitanus</i>	18	81	4	103	111
<i>odoratus</i>	4	33	52	89	12
<i>pseudocicera</i>	74	2	1	77	178
<i>annuus</i>	33	30	7	70	665
<i>gorgoni</i>	61	8	1	70	306
<i>tuberosus</i>	7	38	20	65	3563
<i>latifolius</i>	4	36	12	52	3176
<i>blepharicarpus</i>	48	0	1	49	403
<i>rotundifolius</i>	5	29	11	45	174
<i>marmoratus</i>	36	4	1	41	264
<i>sylvestris</i>	4	1	32	37	3992
<i>chloranthus</i>	4	19	2	25	34
<i>cassius</i>	8	4	2	14	61
<i>basalticus</i>	6	0	1	7	28
<i>ciliolatus</i>	3	1	3	7	28
<i>amphicarpos</i>	4	2	0	6	15
<i>chrysanthus</i>	4	1	1	6	24
<i>cirrhosus</i>	1	1	2	4	28
<i>stenophyllus</i>	2	0	2	4	27
<i>gloeospermus</i>	2	1	0	3	9
<i>heterophyllus</i>	0	2	0	2	115
<i>hirticarpus</i>	2	0	0	2	4
<i>belinensis</i>	1	0	0	1	5
<i>grandiflorus</i>	0	0	1	1	37
<i>mulkak</i>	1	0	0	1	27
<i>lentiformis</i>	0	0	0	0	1
<i>lycicus</i>	0	0	0	0	4
<i>phaselitanus</i>	0	0	0	0	2
<i>trachycarpus</i>	0	0	0	0	2
<i>tremolsianus</i>	0	0	0	0	118
<i>undulates</i>	0	0	0	0	4
Total	882	1,256	273	2,411	18,147

In situ species richness and complementarity analysis

Patterns of specific richness, based on the germplasm accession and herbarium specimen data, were analyzed

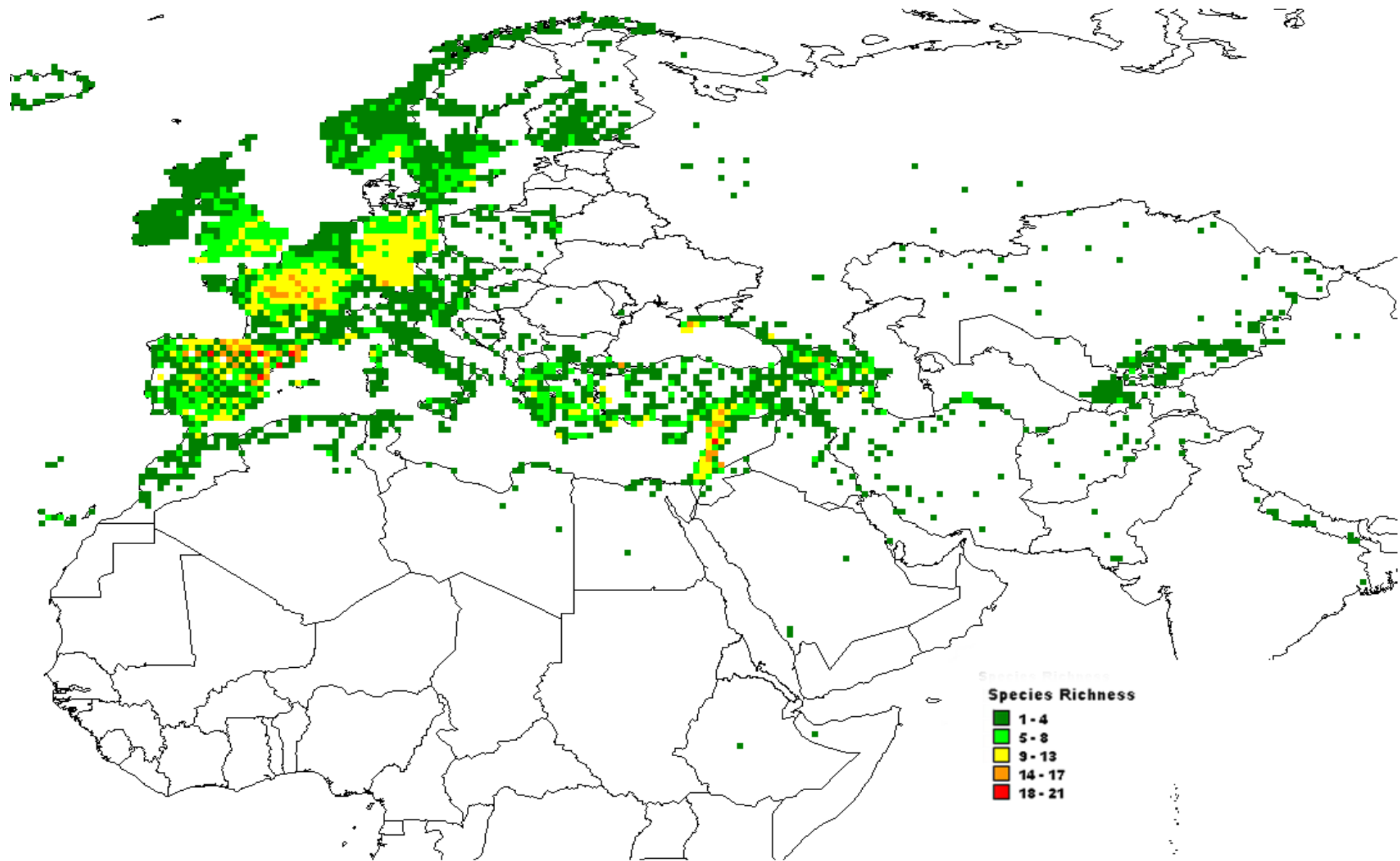
- Hotspots of species diversity identifies

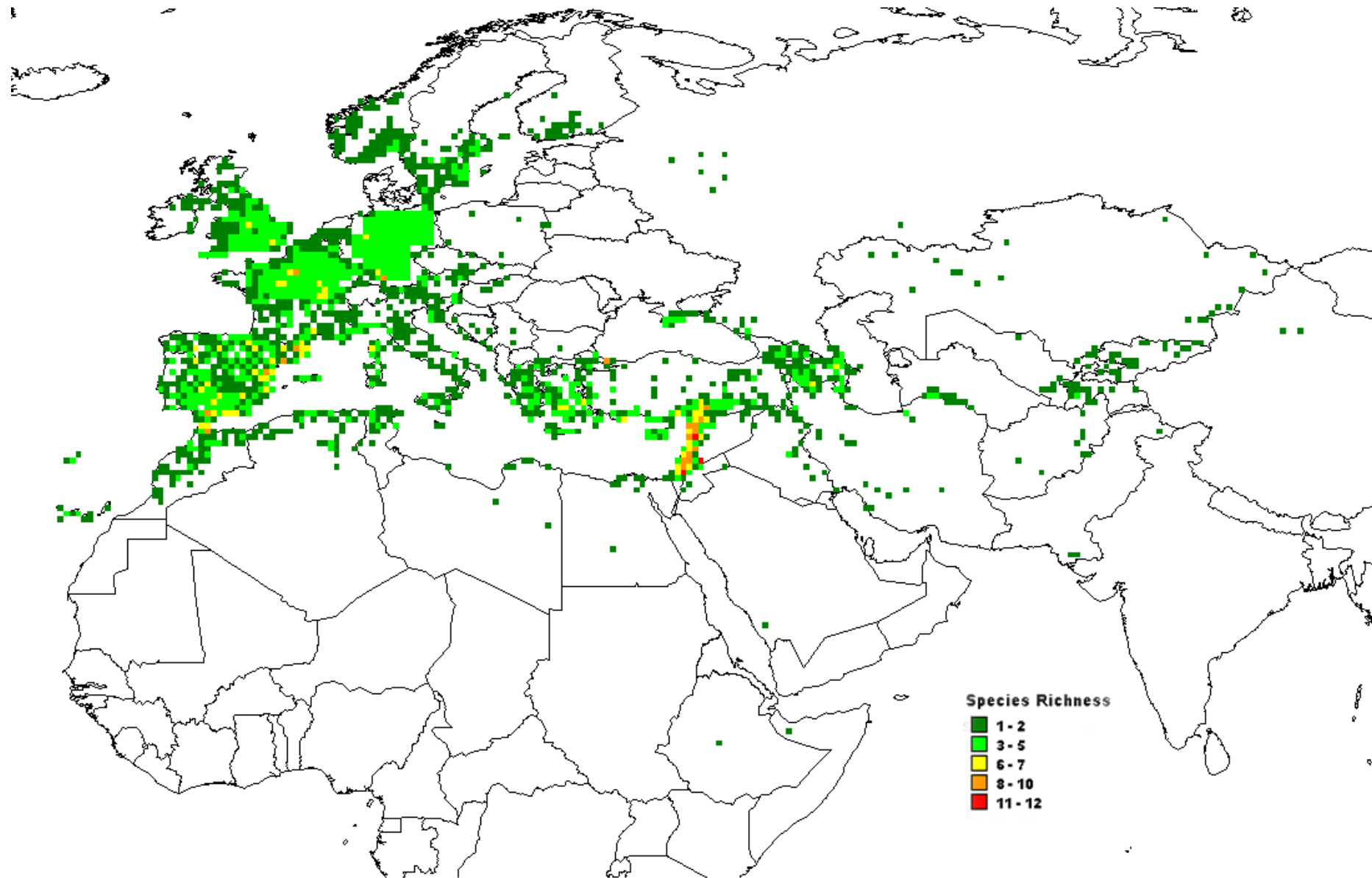
Complementarity analysis is carried out to identifying the minimum number of 100 x 100 km² grid cells that will capture the maximum number of species.

- Putative reserves were selected

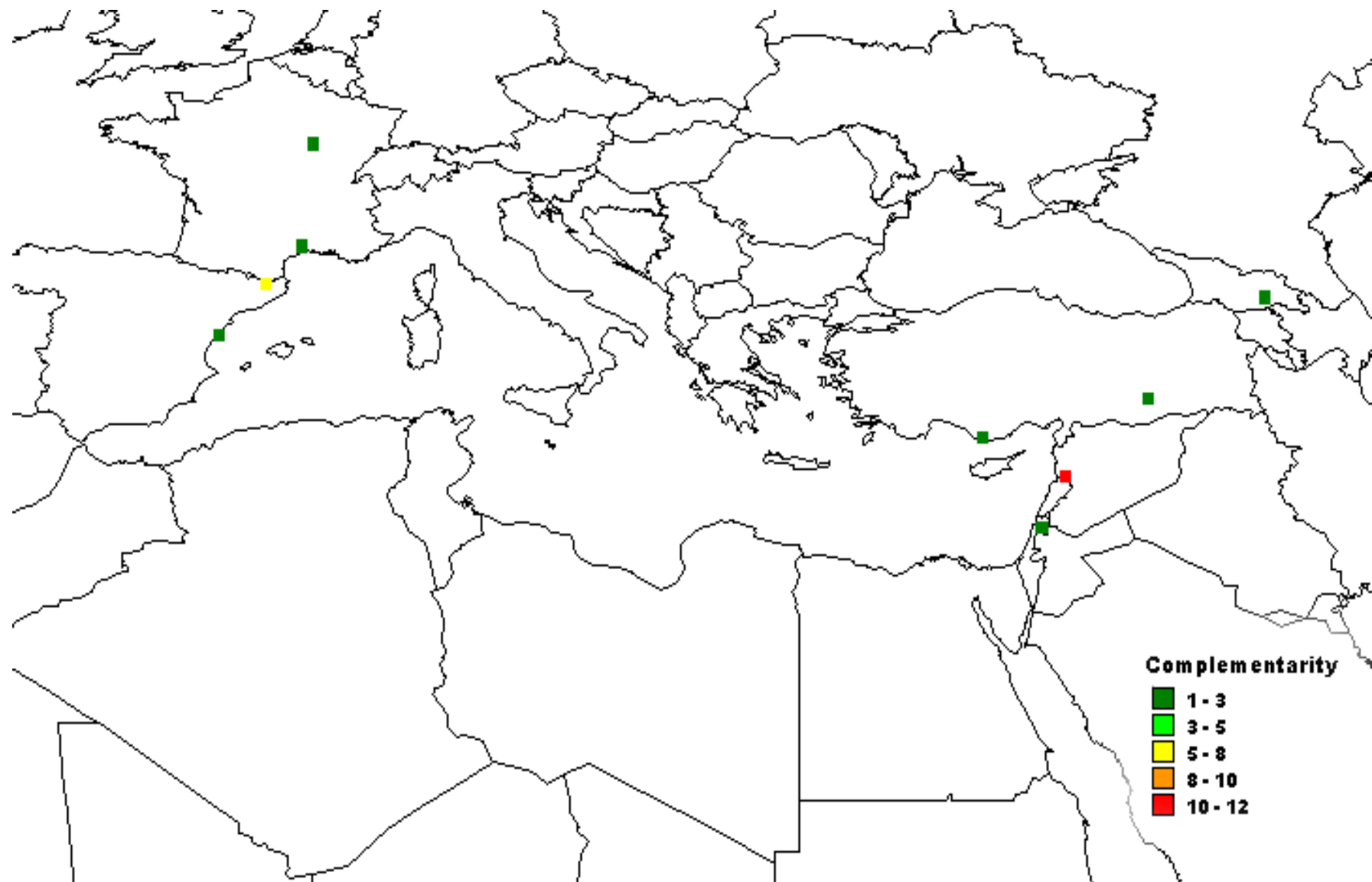
Species richness and complementarity were analysed for all *Lathyrus* sections

Only the sections *Lathyrus* and *Clymenum* are presented here

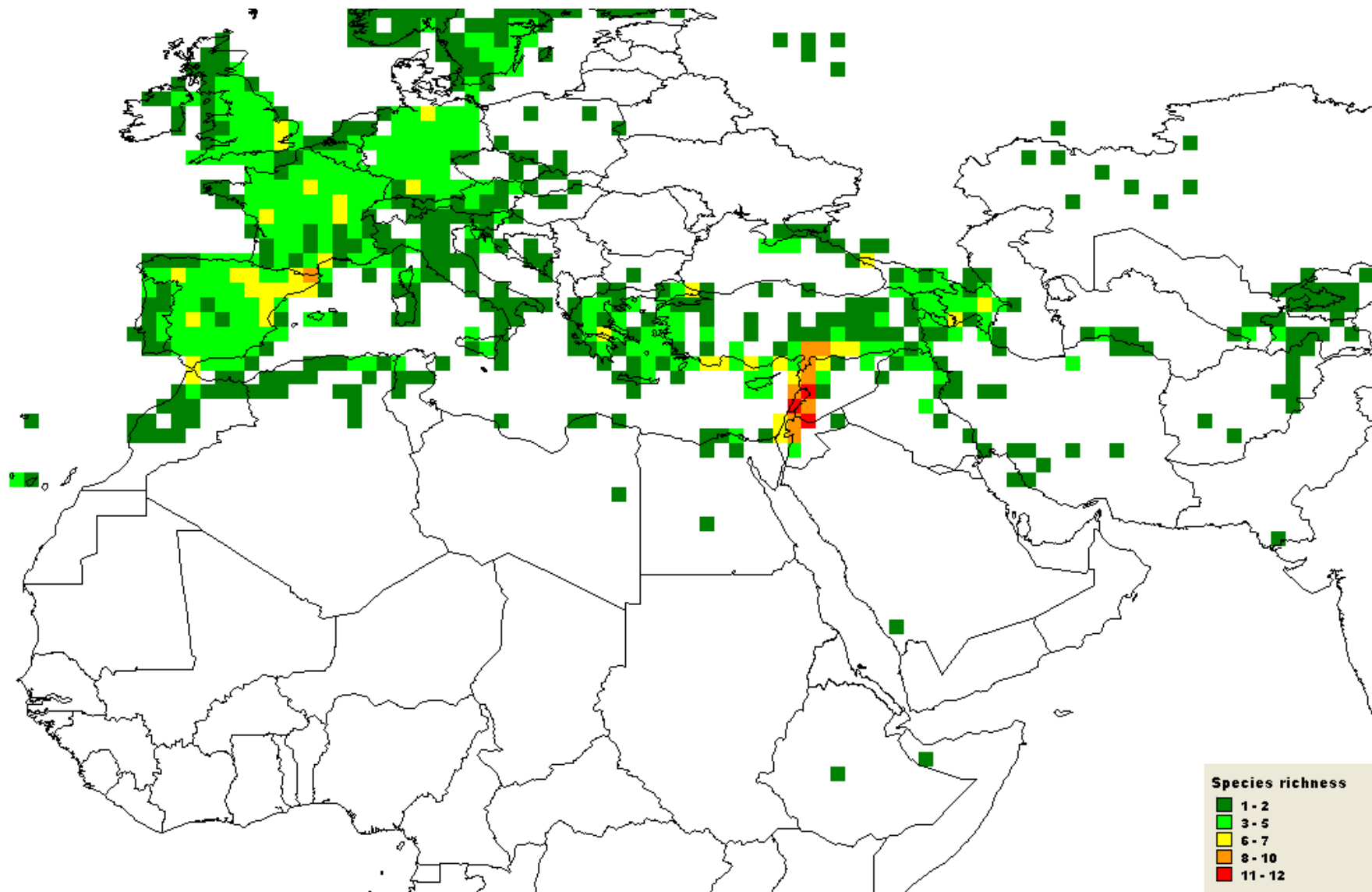


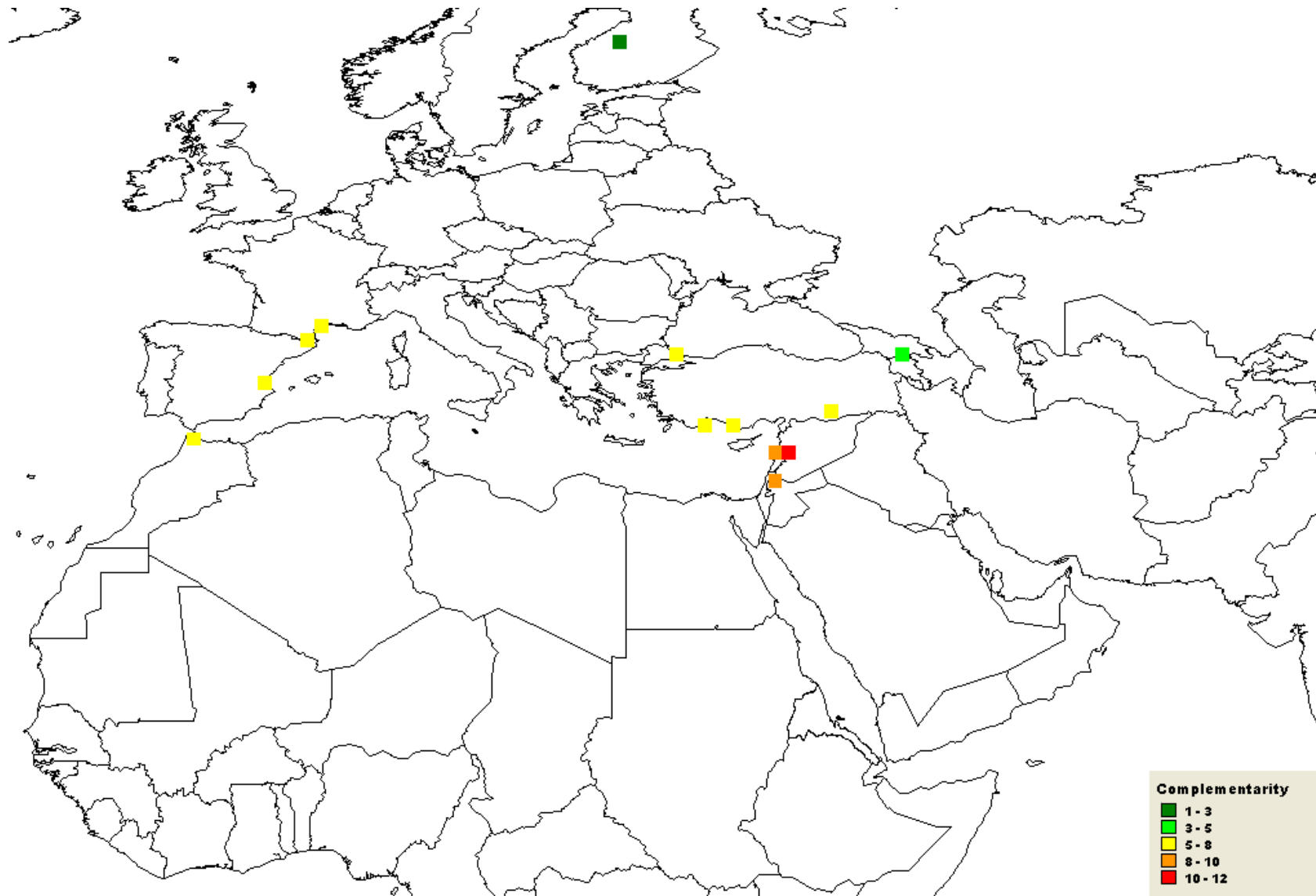


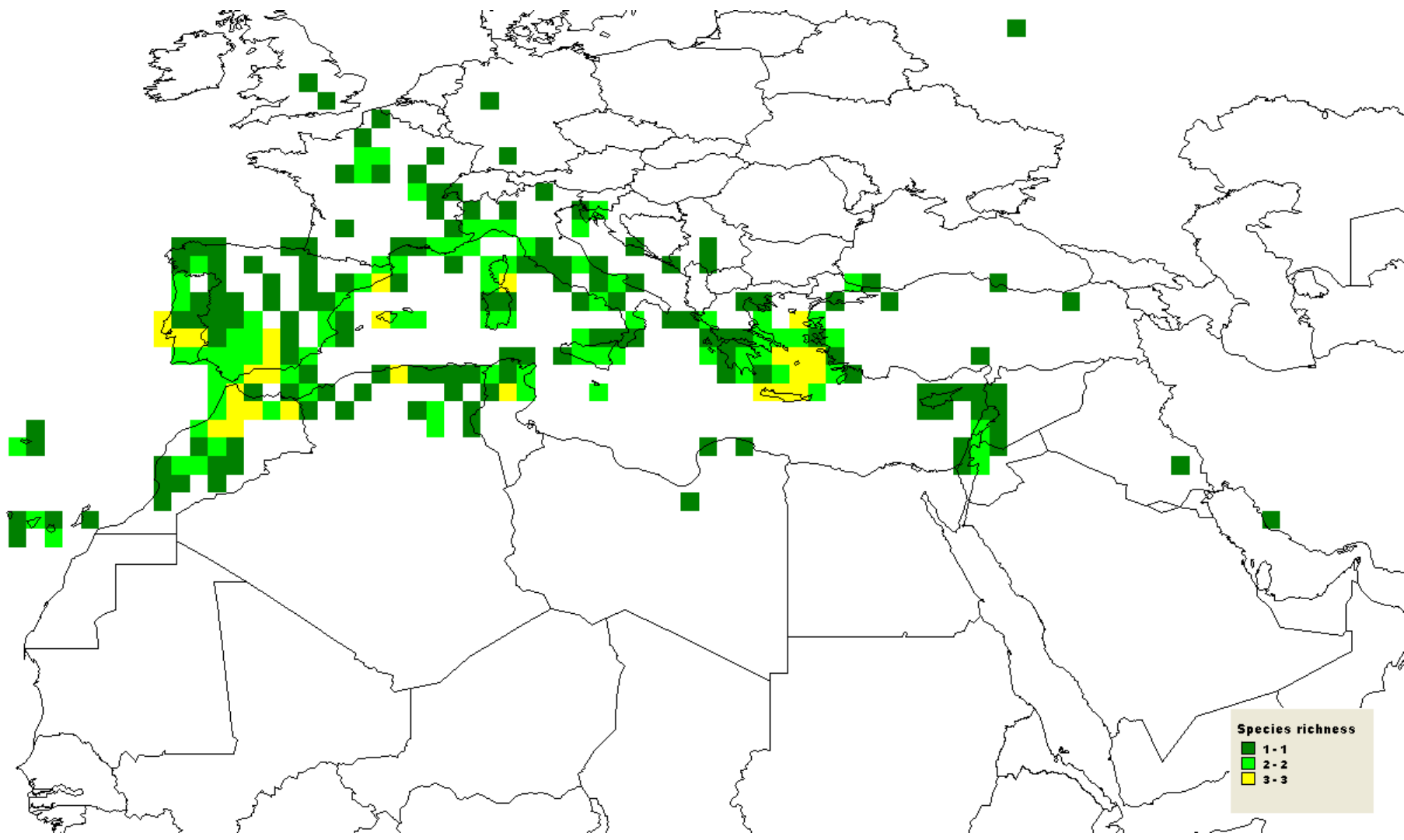
Species richness for unique herbarium and germplasm accessions of 37 priority *Lathyrus* species



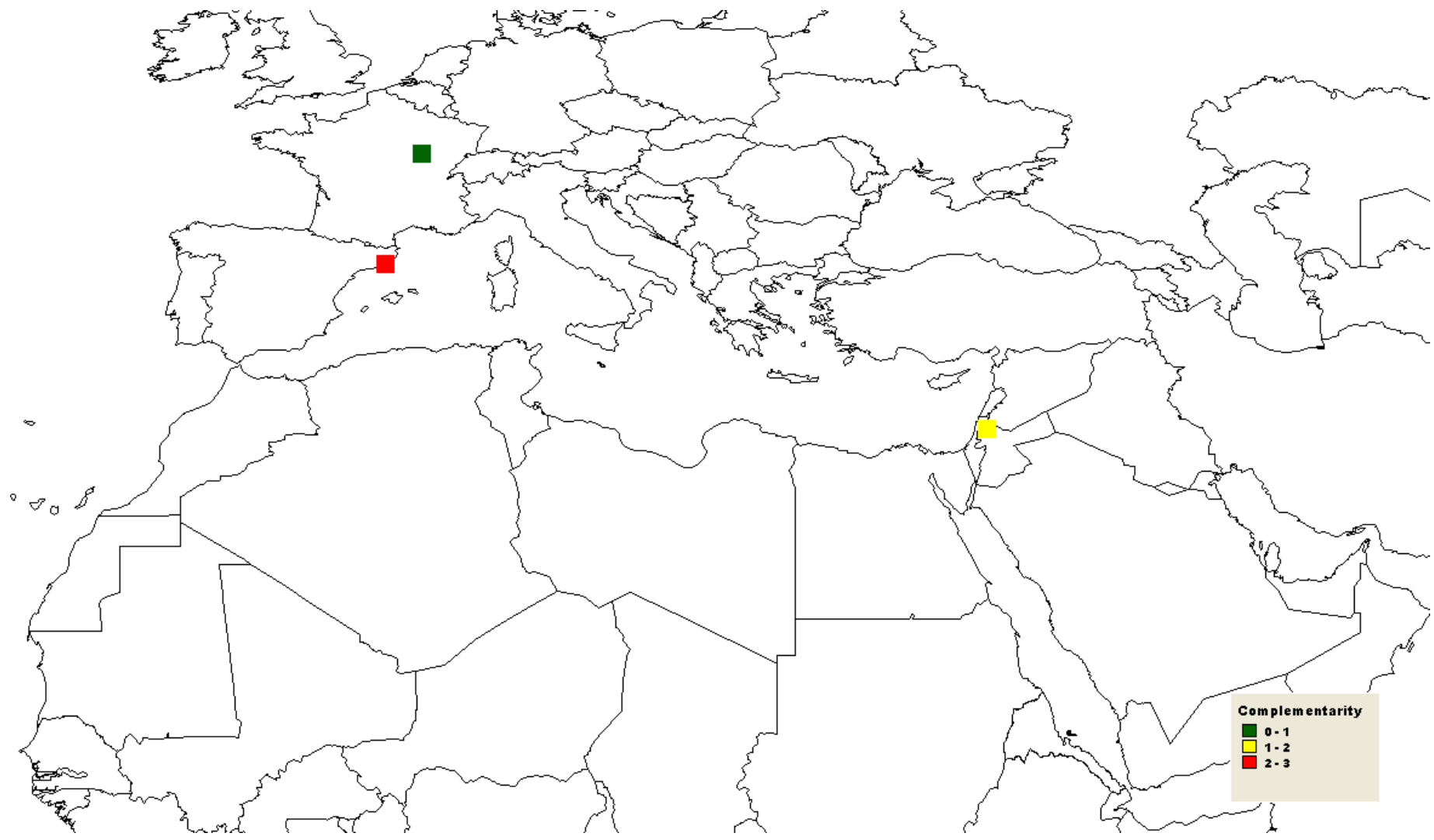
Location of complementarity analysis for priority *Lathyrus* species diversity hotspots

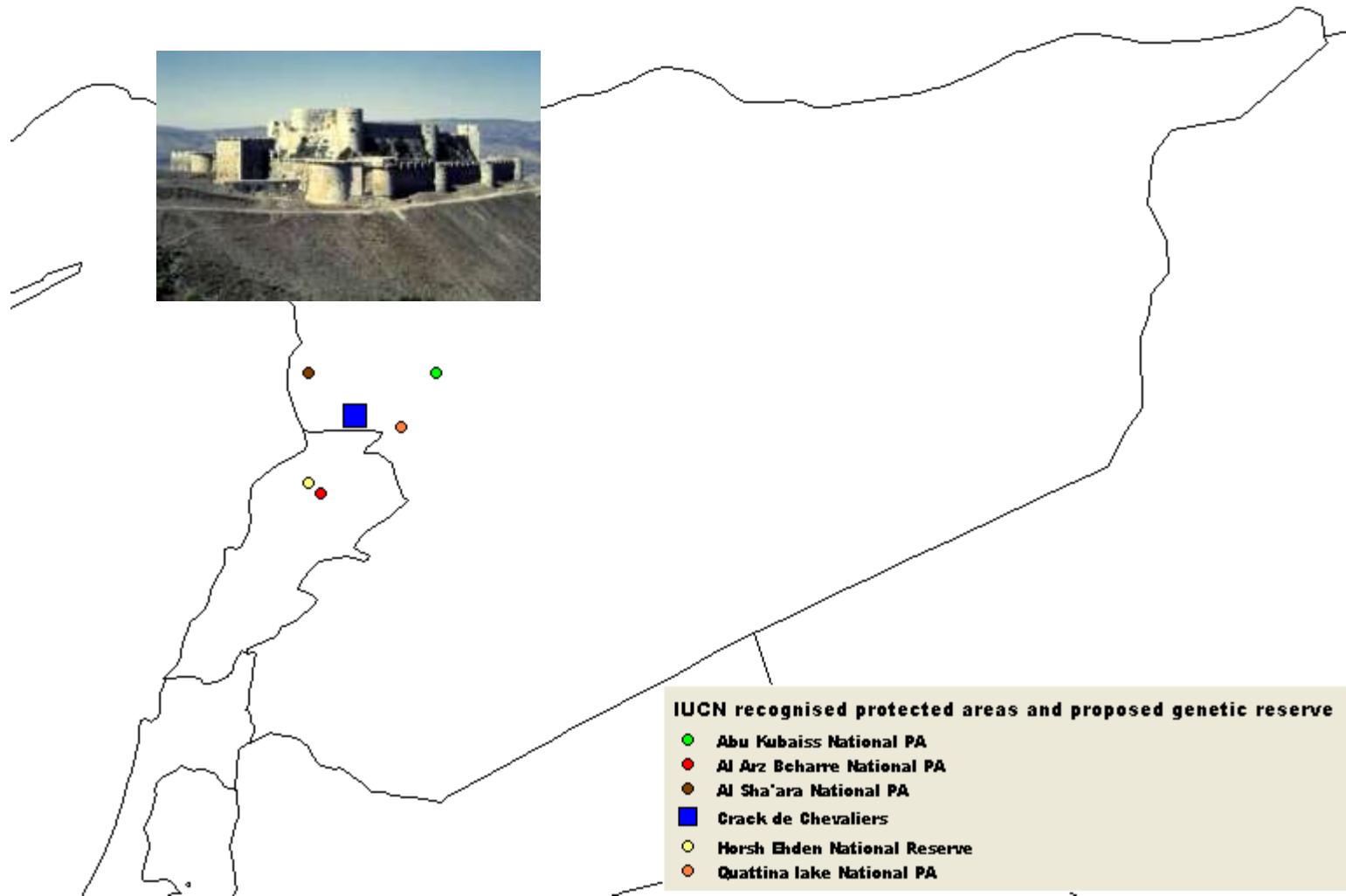






Species richness for priority species of section *Clymenum*





Location of priority species complementary hotspots with associated IUCN recognised protected areas

A Case Study for Grass peas



Grass pea (*Lathyrus sativus* L.), known as Chickling pea or Indian pea,

Annual legume crop of economic and ecological significance in South Asia and Sub-Saharan Africa, and to a limited extent in some countries of CWANA.

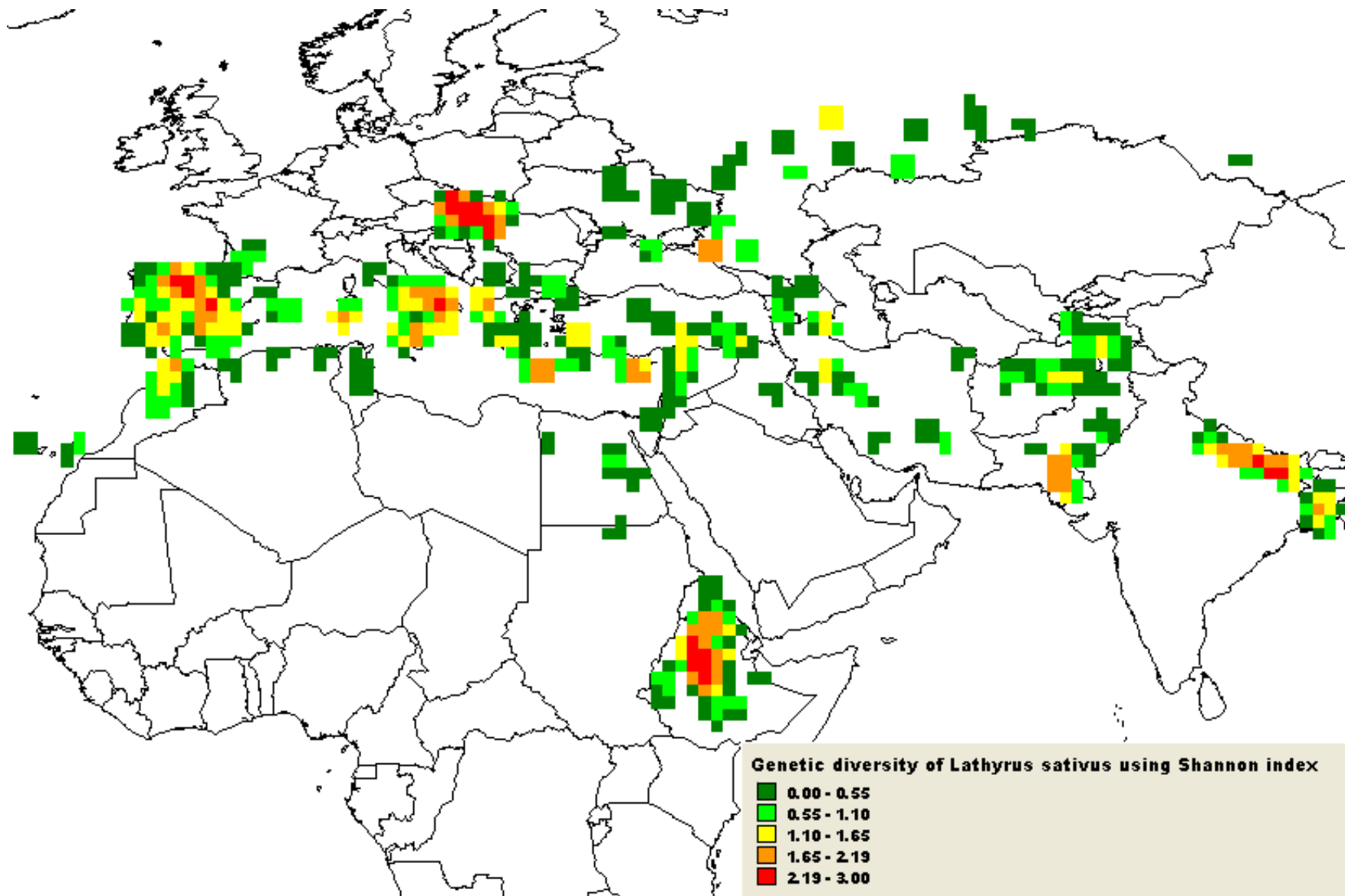


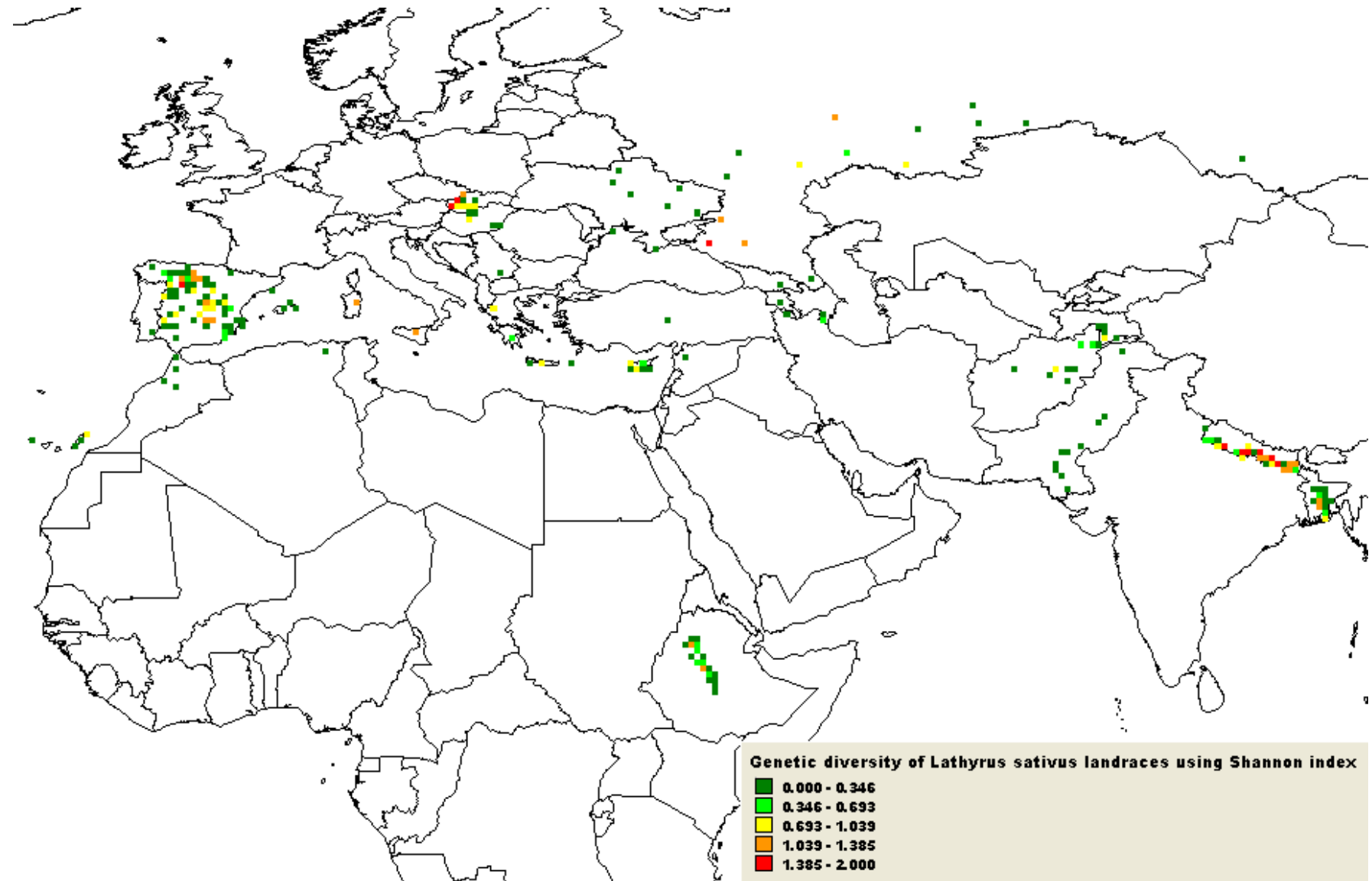
L. sativus is widely cultivated for human consumption, fodder and green manure.

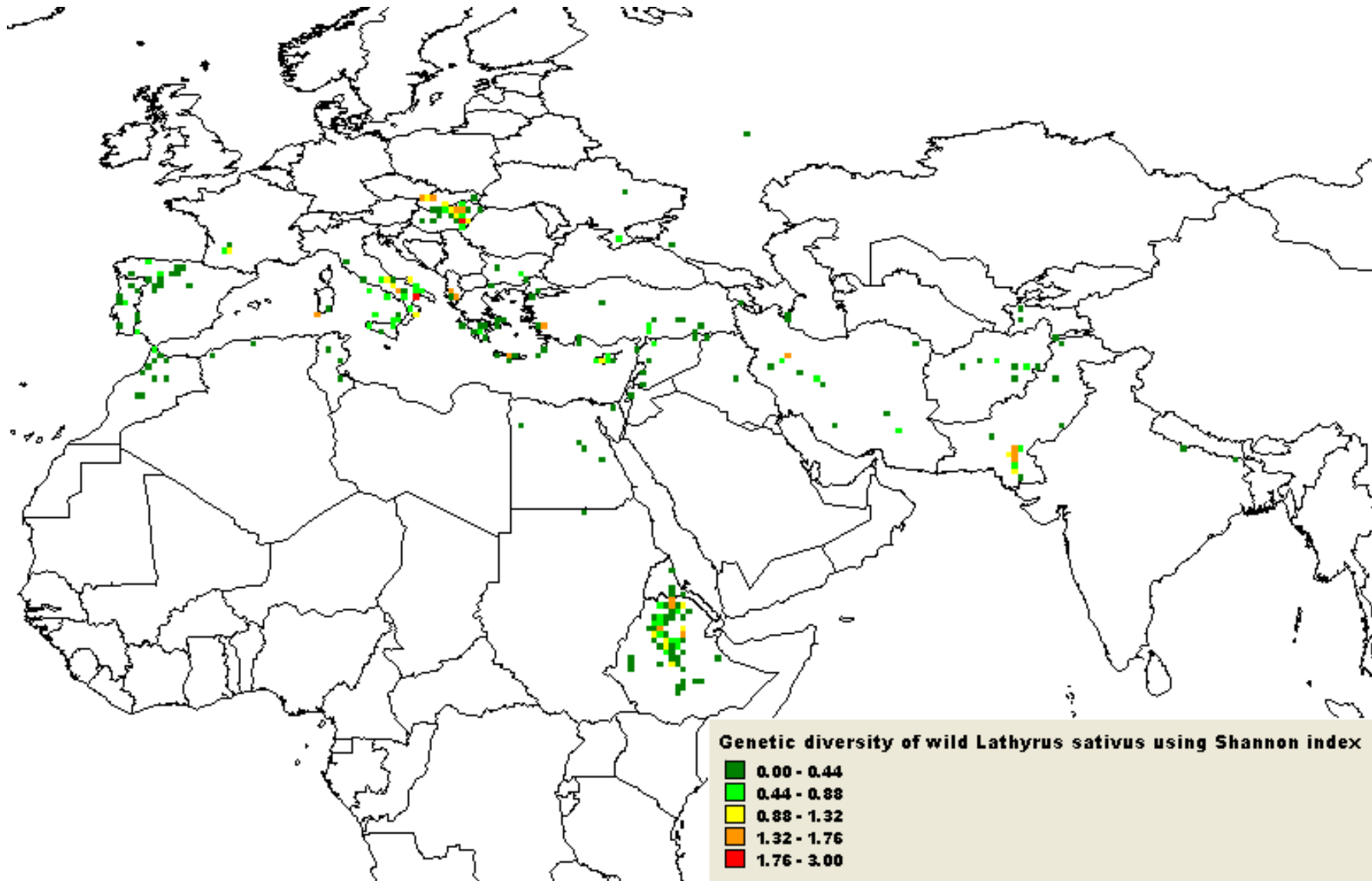
Considered by farmers as an important low risk aversion crop



It is nutritionally equivalent with other grain legume species; But, may contain 0.1-2.5% ODAP which have been found to be neurotoxins, the causative agent of crippling, irreversible neurological disorder, Lathyrism







Conclusions

The research illustrates how the existing geo-referenced passport data associated for *Lathyrus* species can be used for a comprehensive gap analysis;

Gap analysis is an effective tool to fully address the need for a more comprehensive and complementary conservation strategy that encompasses both *in situ* and *ex situ* applications;

The study of herbarium and germplasm accessions' passport and collection data coupled with ecogeographic analyses can quantify the completeness of current *in situ* and *ex situ* conservation actions and identify gaps in conservation diversity at both the taxon and geographic level that in turn helps in the prioritisation of future conservation actions;

This basic methodology could be successfully applied to assist the development of national and regional conservation strategies for crop wild relative diversity;

West Asia, mainly Syria and Turkey are confirmed as the centres of diversity for *Lathyrus* priority species;

Lathyrus diversity and its threats should continuously be assessed and monitored.



Thank you