IMPORTANCE OF AGROBIODIVERSITY CONSERVATION

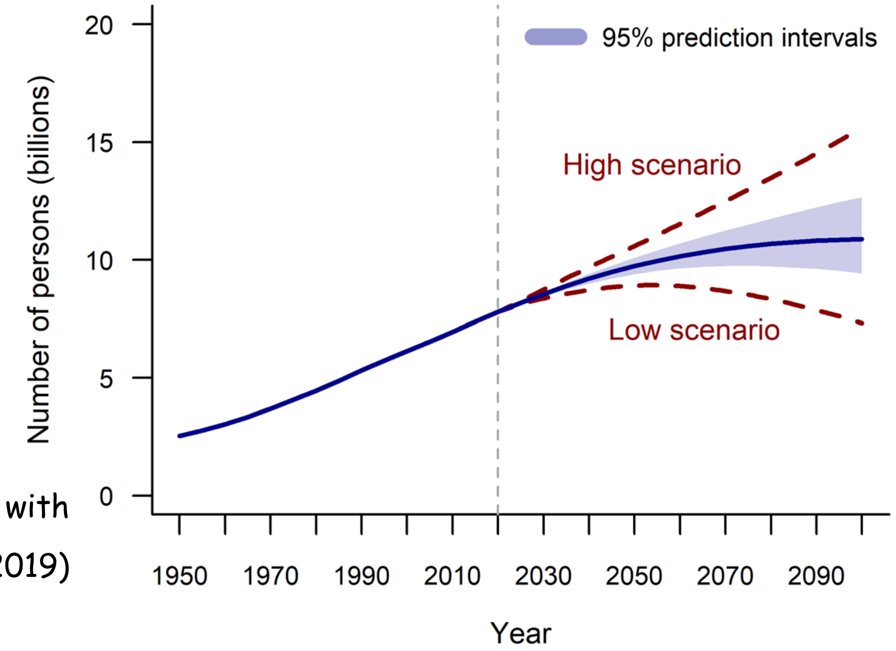
A.L. Tsivelikas and GRS team

Critical Challenges in Agriculture

A. Ensure access to enough and nutritious food

- **15th November 2022**
  - ✓ The day of 8 billion people

- By 2050…
  - ✓ World population will grow to 9.2 billions (annual growth rate 0.7%)



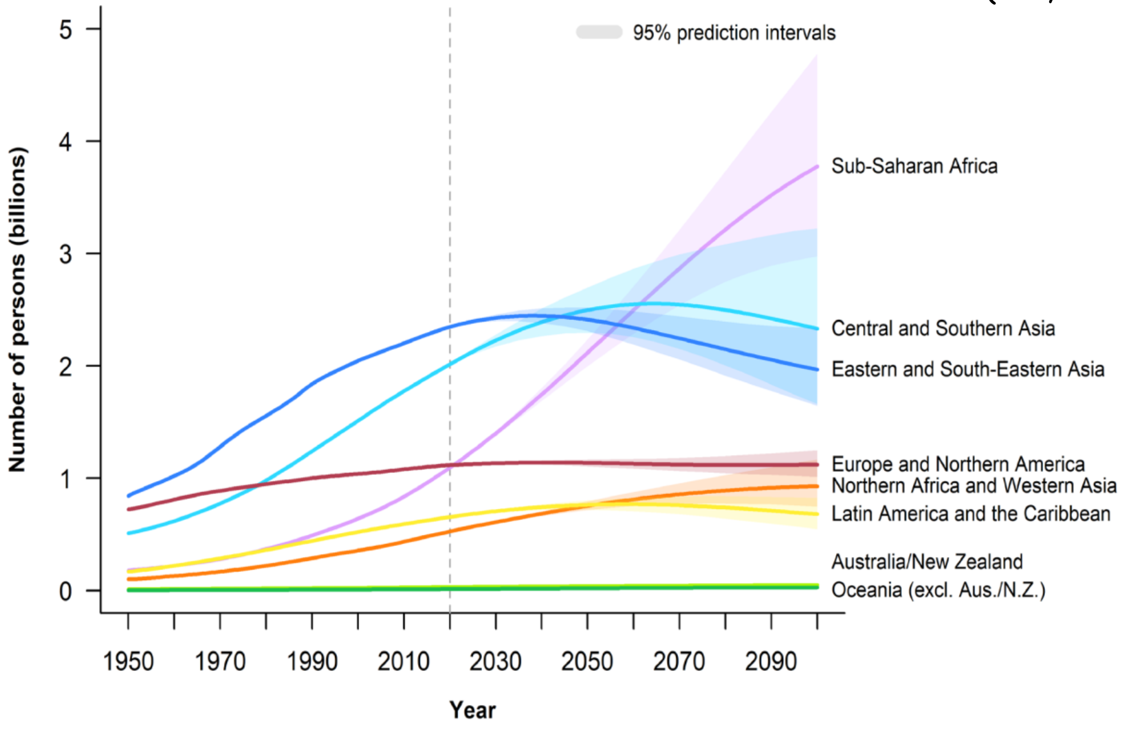
World population estimates and projections with prediction intervals and high/low scenarios, 2020 – 2100 (UN, 2019)

1960	3 billion
1975	4 billion
1987	5 billion
1999	6 billion
2011	7 billion
2022	8 billion
2037	9 billion
2058	10 billion

Critical Challenges in Agriculture

- Living under extreme poverty (<$2.15 per person per day at 2017 purchasing power parity):
  - ✓ The share of people is declining for three decades, falling at 8.4% in 2019, but reaching at 9.3% in 2020 due to covid-19 crisis (The World Bank, 2022).

Population estimates, 1950-2020, and projections with prediction intervals, 2020-2100, by region (UN, 2019)



Two targets…

- ✓ **Increasing production and energy content (carbohydrates, protein, fat) of staple foods**
- ✓ **Moving from "green revolution" to "revolution with greens"**

Critical Challenges in Agriculture

B. Adaptation to climate change

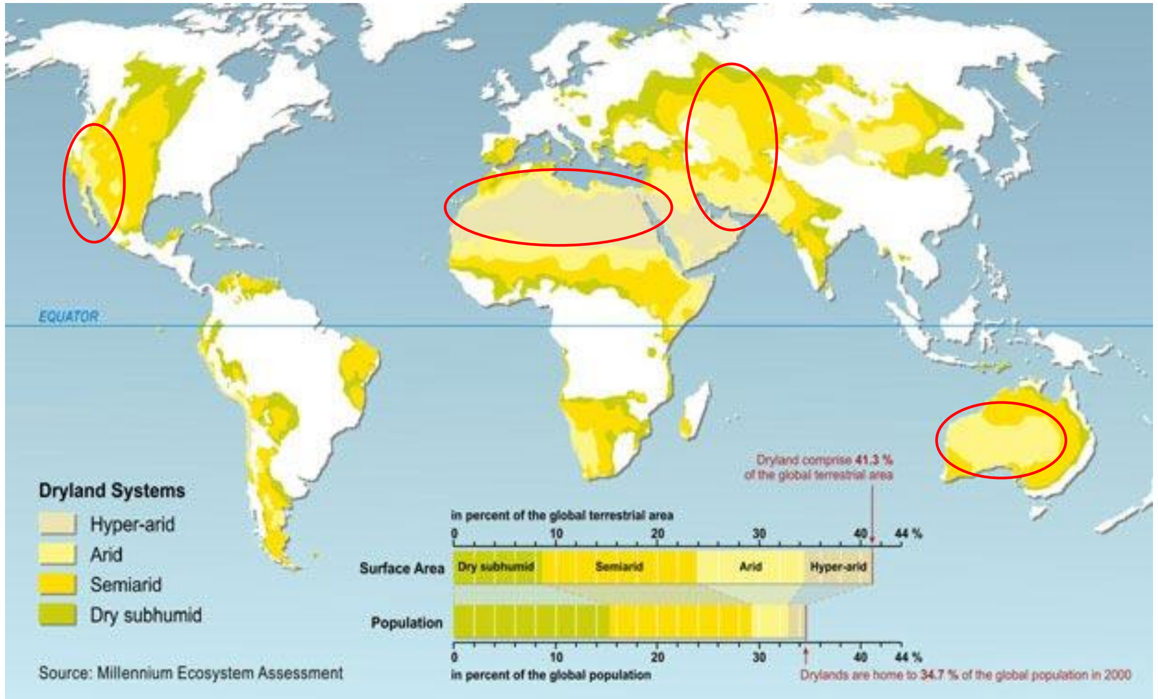
Global Climate Models all converge with regard to projections of:

- ✓ Increased frequency of drought, and
- ✓ high temperatures

In:

- ✓ central North America,
- ✓ northern Africa,
- ✓ central Asia, and
- ✓ western Australia

(Girvetz *et al.* 2009, Elert & Lemonick 2011)



Source: [Millennium Ecosystem Assessment](#) (2005)

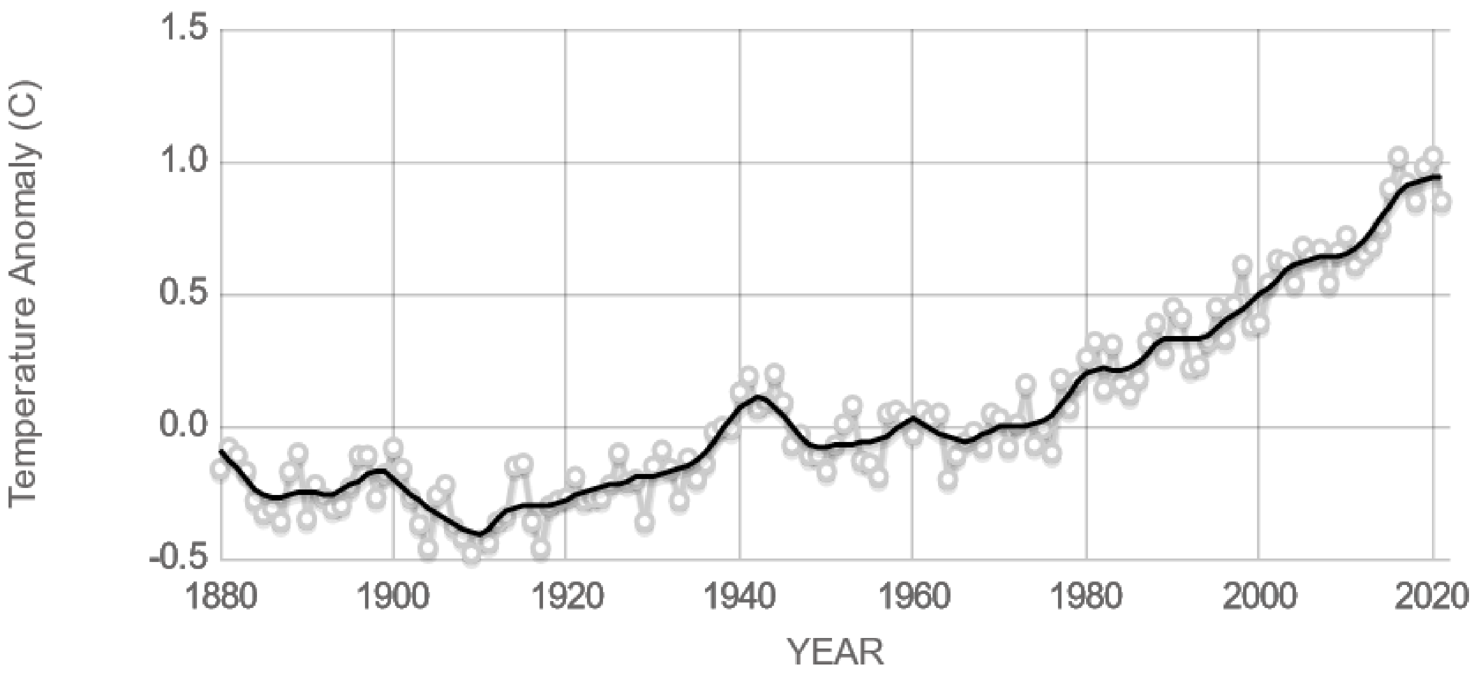
http://oceanworld.tamu.edu/resources/environment-book/Images/drylandmap.jpg
Visited October 21, 2013

Critical Challenges in Agriculture

B. Adaptation to climate change (continue…)

Heat stress will increase vulnerability ofcrops ..more than drought.
(Semenov & Shewry 2011)

- ✓ The years 2013-2021 all ranked among the ten-warmest years on record (https://www.noaa.gov/)
- ✓ The year 2020 tied with 2016 for the hottest year on record since recordkeeping began in 1880 (source: NASA/GISS)



Source: climate.nasa.gov

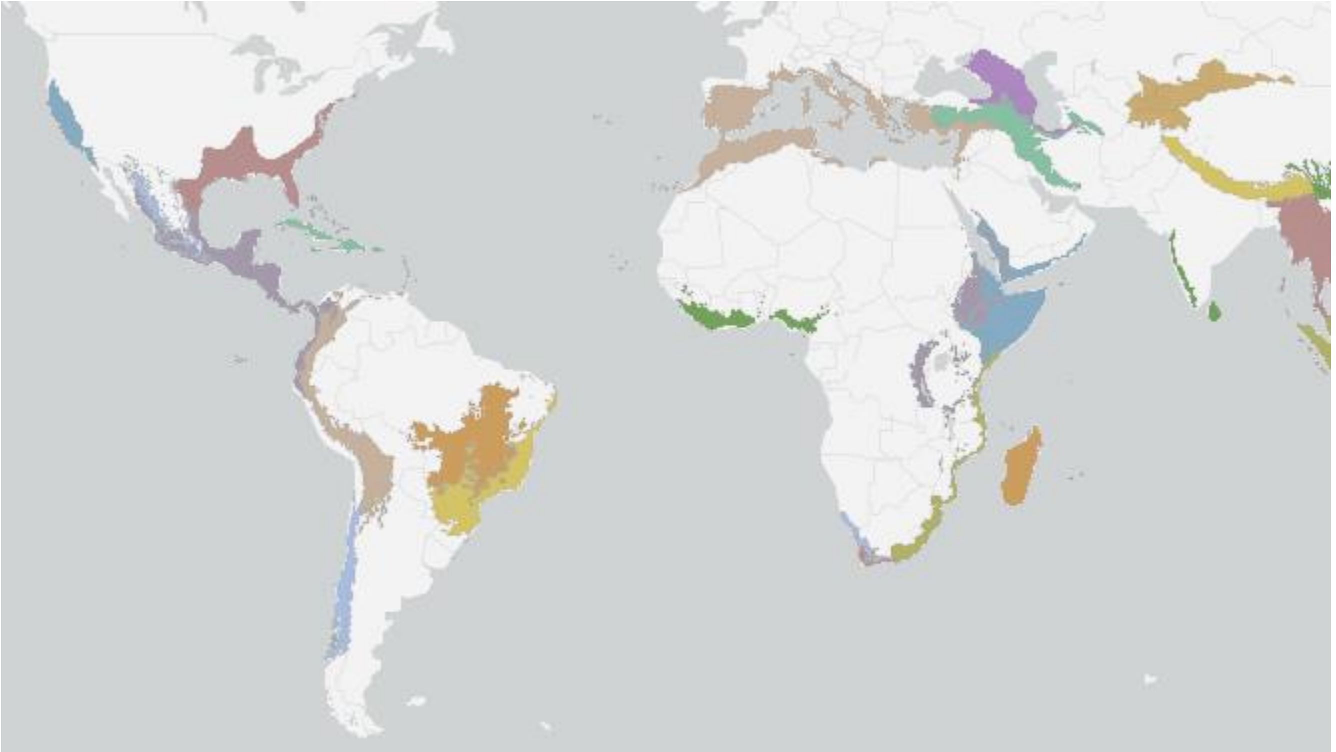
This will require to aim for yield and environmental adaptation in unprecedented/different circumstances!

Biological Diversity

"…the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems."

(CBD, 1992)

Biodiversity comprises all living things together with their characteristic traits. Included with these traits are the cultural traits which characterize different people living on Earth.



The 36 global biodiversity hotspots (source: Conservation International)

Levels of Biological Diversity

Pick a trend

Level	Definition	Trends
Ecosystem diversity	the variety of habitats, biological communities and ecological processes affecting the adaptation of performance of a species	✓ Deforestation ✓ Population growth ✓ Urbanization
Species diversity	the numbers of species existing in one site, country or region (qualitative richness)	✓ Alien species ✓ Changes in agriculture
Genetic diversity	the genetic variation (alleles/genes) existing within all individuals of a species, between populations of a species as well as between species	✓ GMOs ✓ Narrow of genetic base

Agricultural Biodiversity (Agrobiodiversity)

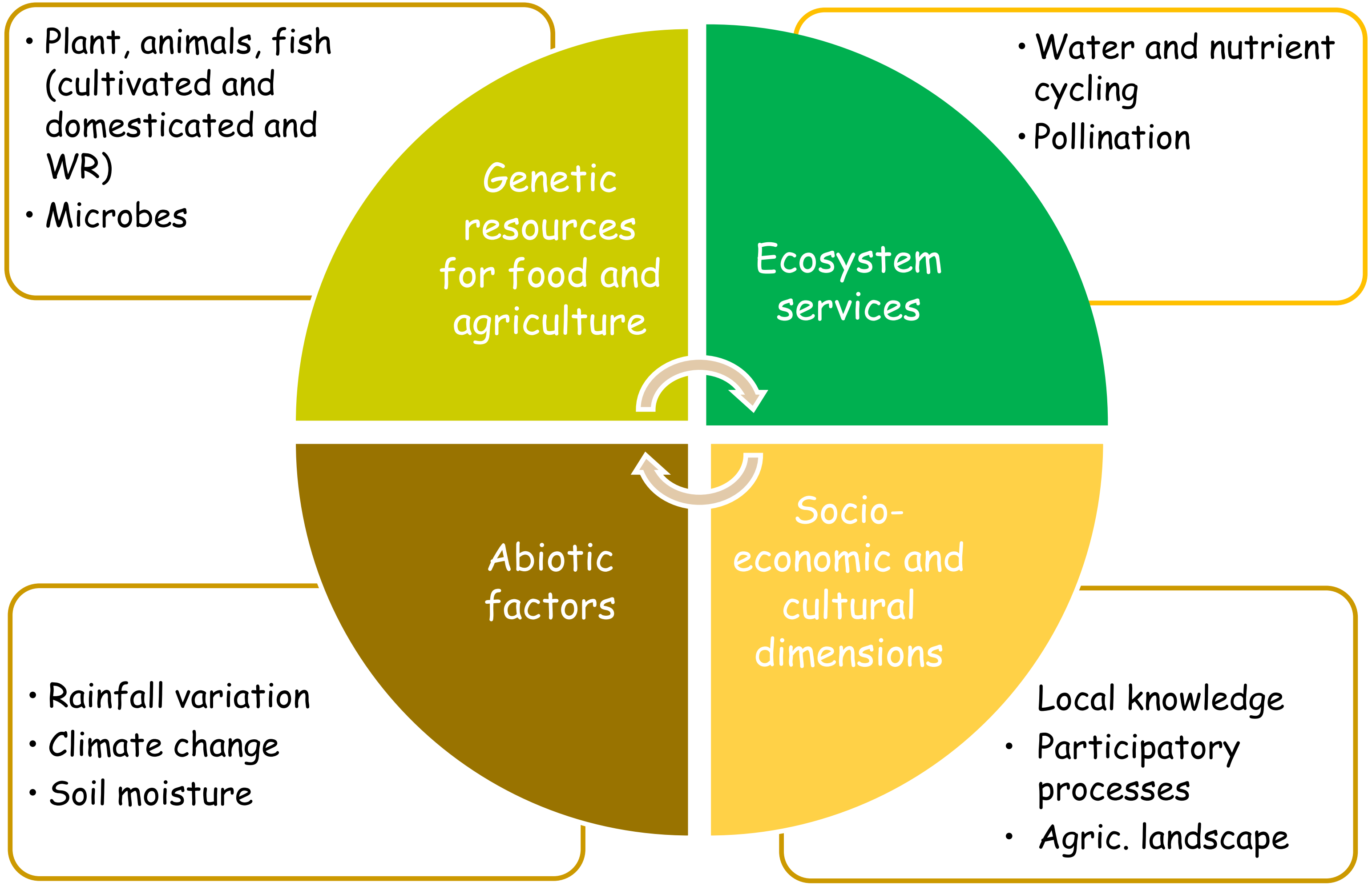
The variable forms and functions of all living organisms that are useful in agriculture today or have potential usefulness in the future.

- ✓ It includes all crop plants, domestic animals, yeasts and other useful food processing organisms, N and P-fixing soil bacteria, etc., as well as their ancestral or related wild species at the genetic, species and ecosystem levels, which are necessary to sustain the key functions of the agro-ecosystem.

It is the outcome of the interactions among genetic resources, the environment and the management systems and practices used by farmers and represents the basic element for safeguarding national and global food security.

Agricultural Biodiversity (Agrobiodiversity)

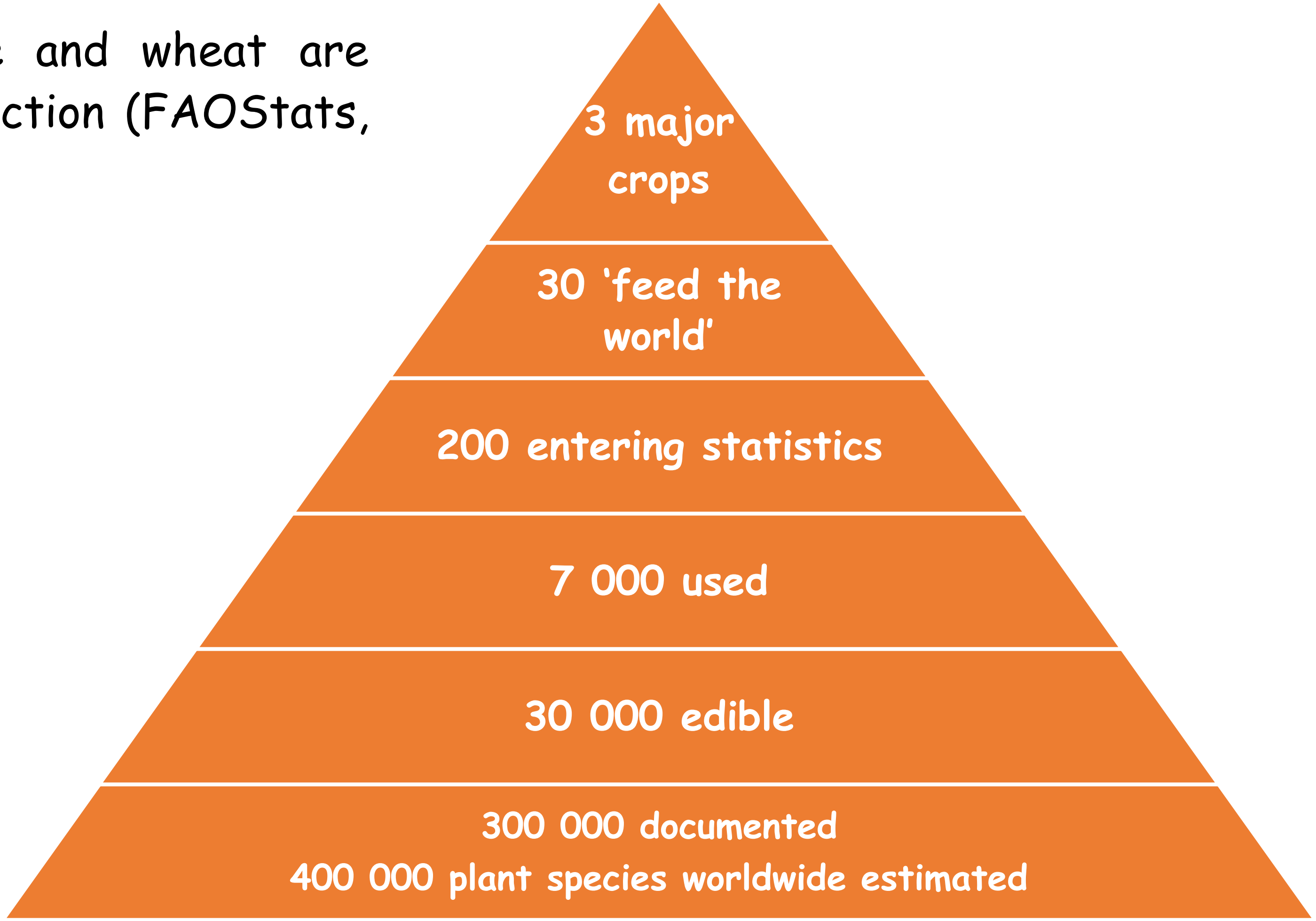
Components of Agrobiodiversity (CBD, 2011):



Narrowing Consciously our Choices

However…

- Three major crops: maize, rice and wheat are holding >40% of total crop production (FAOStats, 2021)



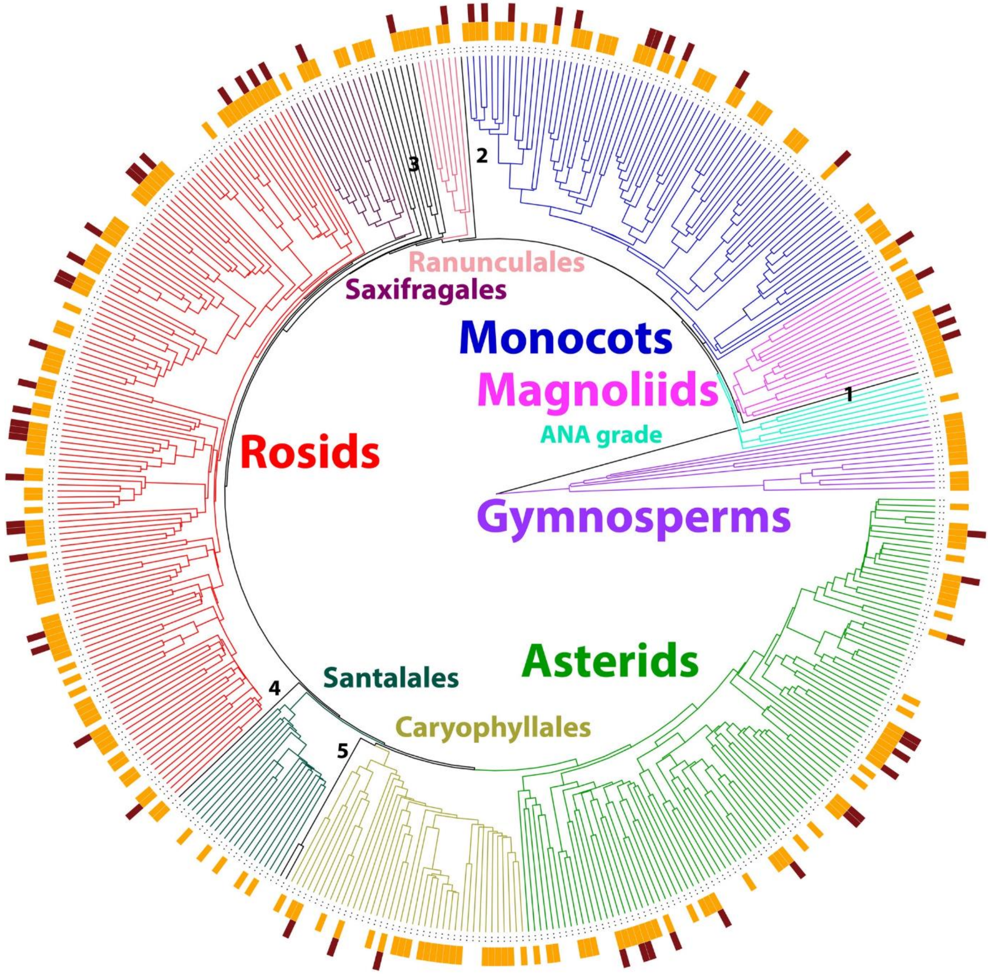
source: FAO, 1996

Enriching "fields" with Novel Diversity

Plant Genetic Resources

- The overall genetic diversity of cultivated species and their wild relatives, which have the potential to contribute in crop breeding (Hawkes, 1983).

Photo: ICARDA

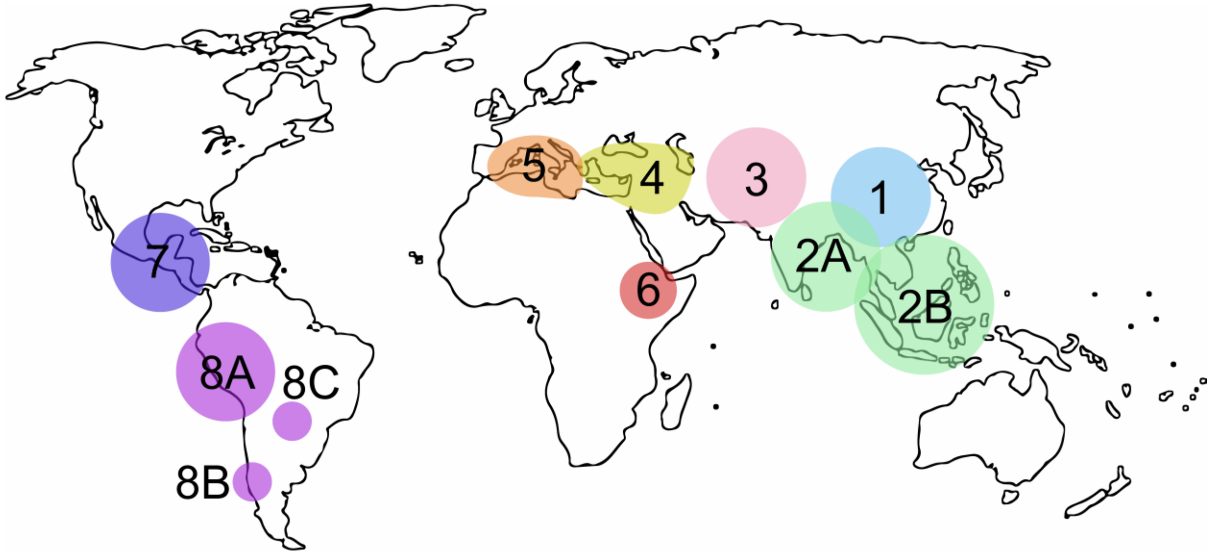


Phylogenetic distribution of edible plants: Adapted from Ulian et al. (2020); Rectangles at the tips of the phylogeny denote the presence of human food plants (orange) and major food crops (brown) in each family.

Centers of Origin of Crops

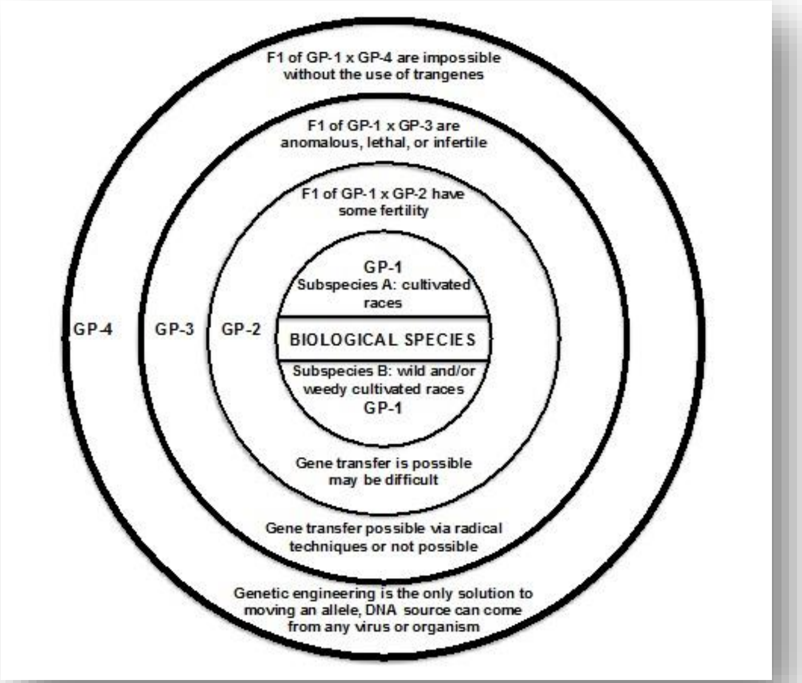
De Candolle (1882) and Vavilov (1926) first realized that crop diversity is not evenly distributed over the globe:

I. China (crops: soybean, buckwheat, rice)
II. a. India, b. Indochina (crops: banana, sugarcane, yam, rice)
III. Central Asia (N. India, Afghanistan, Turkmenistan) (crops: wheat)
IV. Near East (fertile crescent) (crops: wheat, barley, rye, chickpea, lentils, figs)
V. Mediterranean (crops: oat, rapeseed)
VI. Abyssinia (crops: barley, sorghum, millet)
VII. Southern Mexico and middle America (crops: maize, common bean, sweet potato)
VIII. North-eastern south America (Bolivia, Ecuador, Peru) (crops: potato, lima bean, groundnut, cassava)

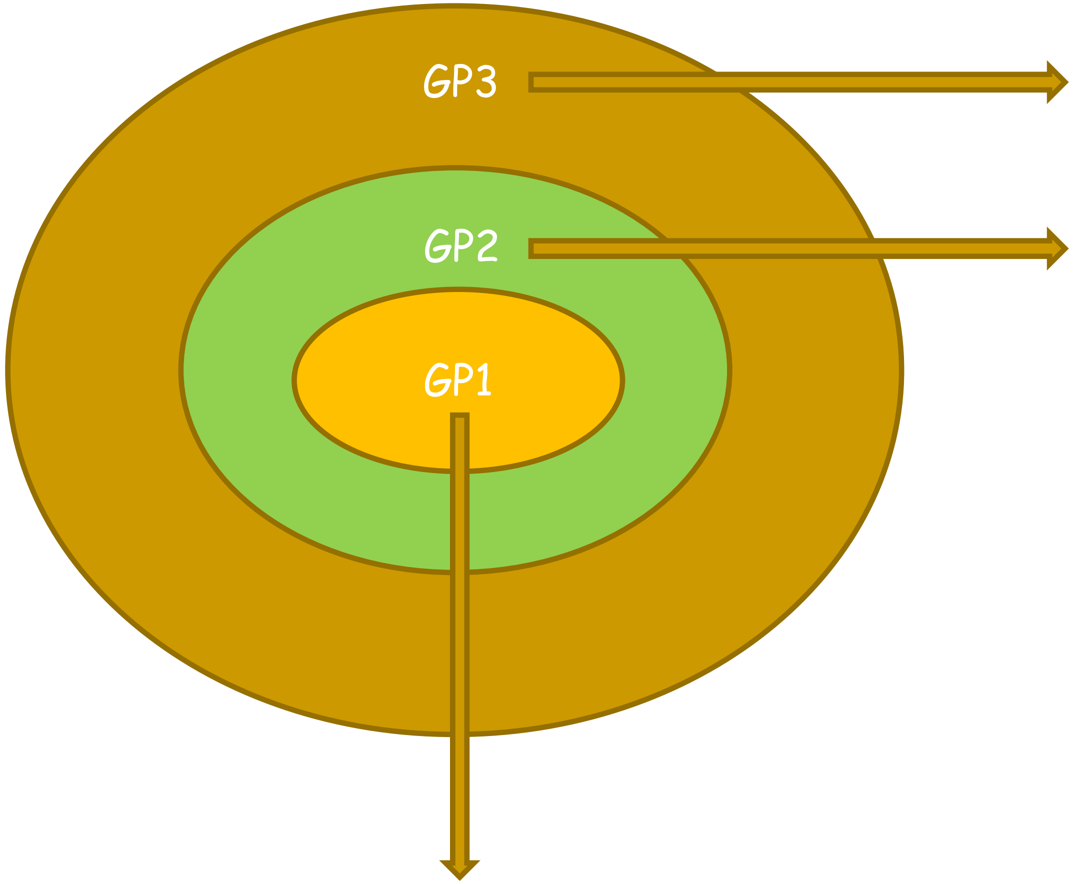


The Genepool Concept

- Examination of relationships among plant species and of their prospects for exploitation in crops genetic improvement, proposed based on the "biological species concept" (Harlan and de Wet, 1971) the following three categories:
  - ✓ Primary gene pool (GP1): Types and forms in this category easily cross each other and the offspring are fertile (cultivated species and wild relatives).
  - ✓ Secondary gene pool (GP2): Species that lead to partial fertility on crossing with GP1.
  - ✓ Tertiary gene pool (GP3): Species that lead to sterile hybrids on crossing with GP1 (special techniques are required).



The Wheat Genepool



- ✓ All non-progenitor diploid and tetraploid species (e.g. *Thinopyrum*, *Secale*, etc.)

- ✓ Tetraploid species with one genome common with wheat
- ✓ Diploid *Aegilops* S-genome species from section *Sitopsis*

- ✓ All diploid and tetraploid *Triticum* and *Aegilops* species with A, B and D genomes
- ✓ Landraces, early domesticates

Plant Genetic Resources

- The overall genetic diversity of cultivated species and their wild relatives, which have the potential to contribute in crop breeding (Hawkes, 1983).
  - ✓ Currently grown commercial cultivars
  - ✓ Obsolete cultivars (expired legal protection)
  - ✓ Breeding lines and stocks
  - ✓ Local cultivars/landraces
  - ✓ Primitive forms of crop plants collected from the centres of origin and diversity of the species.
  - ✓ Crop wild relative species

Most of the times…

The term is restricted in the categories of plant germplasm which is not protected by special legislation.

Ex situ Germplasm Collections (Genebanks)

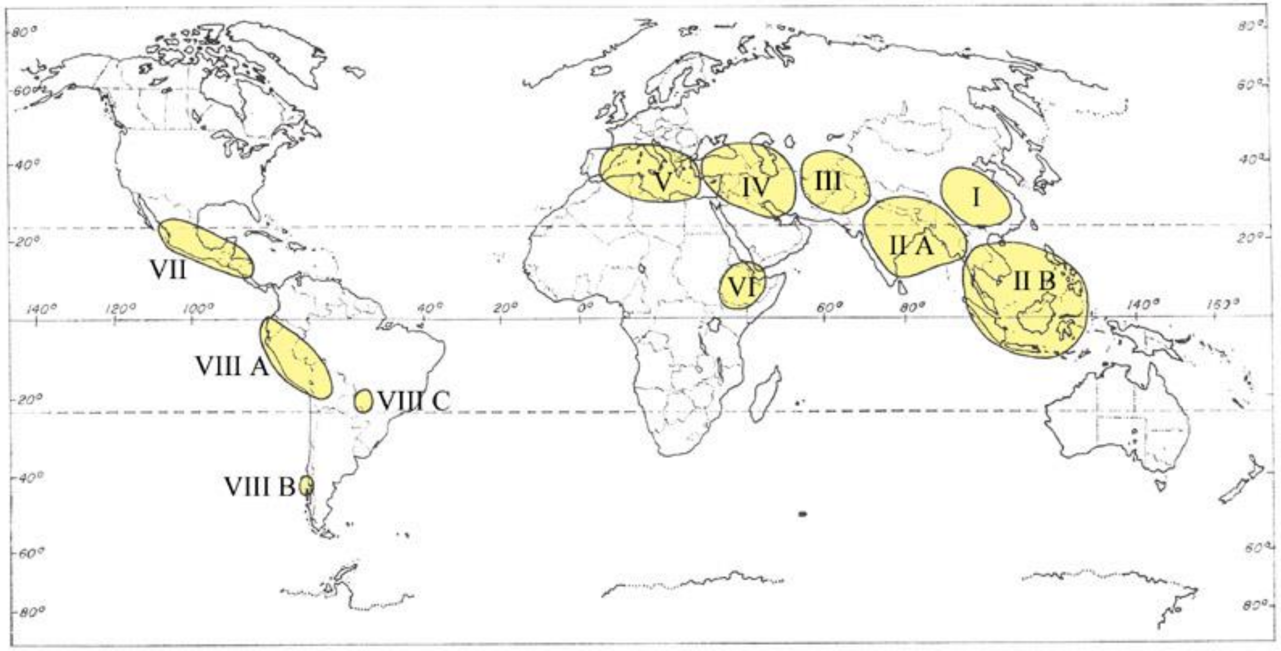
- Increased enormously in number and size over the last decades
  - ✓ Global efforts to conserve plant genetic resources for food and agriculture (PGRFA) … sometimes with support from international community
- Worldwide…
  - ✓ 1 750 genebanks are registered and conserve over 7.5 million accessions, including major crops, minor or neglected crop species, together with trees and wild plants (Hay, 2019).

ICARDA Genebank seed collection

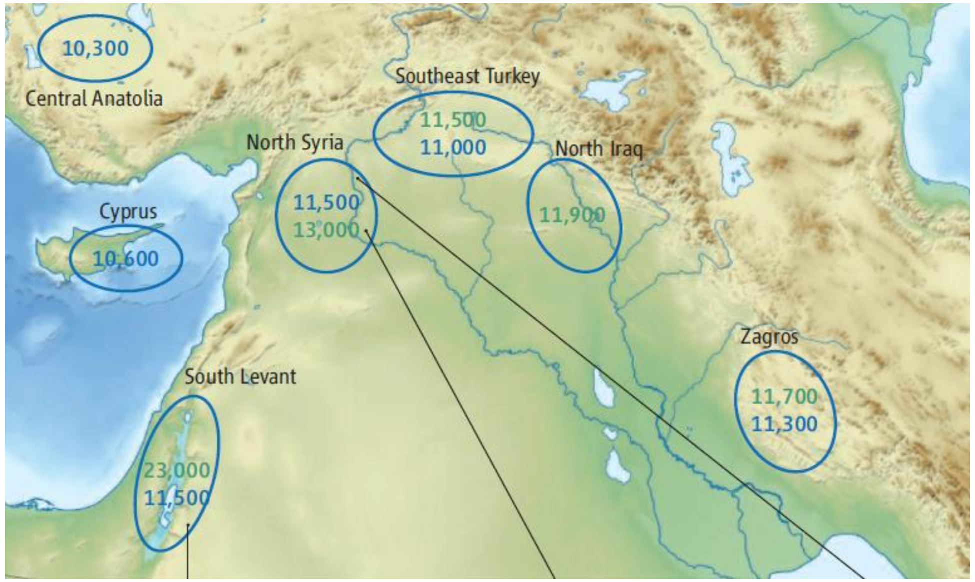
ICARDA's Genebank Collection

At the crossroad of the origin of the species…

- Crossroad between Near East and Mediterranean Centers of Origin.
- More than 65% of the global human calories consumption is "originated" from the CWANA Mega Center of crop origin



At the heart that first crop domestication occurred (Fertile Crescent)…



a) Mortar and pestle from Wadi Hammeh in the southern Levant, 14,000 years ago. b) Bases querns in a room at Jerf el Ahmar, northern Syria and c) Quern from Tell 'Abr, northern Syria, all dated to 11,300 years ago. From Wilcox (*Science* 341, 39 (2013)).

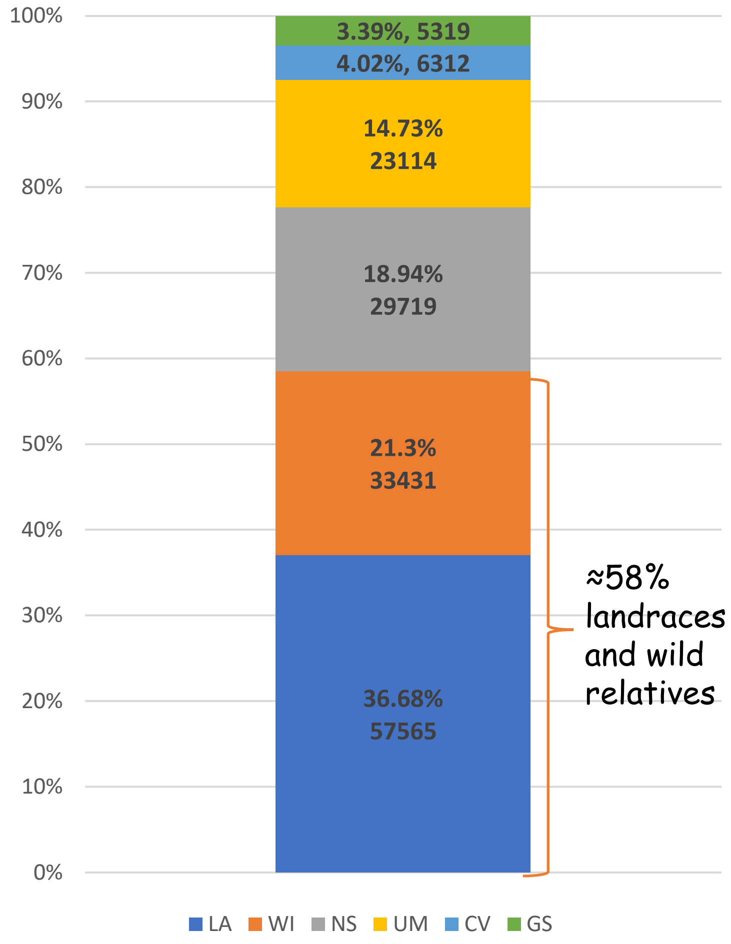
ICARDA's Collection in Numbers

Crop	No of accs.	Crop	No of accs.
Barley	30,242	*Pisum* spp.	4,596
Bread wheat	15,088	*Trifolium* spp.	5,519
Durum wheat	20,353	*Vicia* spp.	6,452
Primitive wheat	1,390	Faba bean	9,654
Aegilops spp.	5,183	Chickpea	14,833
Wild *Triticum*	2,160	Lentil	13,732
Wild *Hordeum*	2,240	Wild *Cicer*	552
Not mandate cereals	285	Wild *Lens*	645
Lathyrus spp.	4,412	Range & Pasture	5,828
Medicago annual	9,068	Others	48
Total			**152,280**

Crop genepool	Global Ranking[1]	% acc. globally
Barley	2nd	19.0
Wheat	4th	14.6
Chickpea	2nd	23.2
Faba bean	1st	89.1
Lentil	1st	43.5
Lathyrus	1st	63.6
Medicago	2nd	15.0
Pisum	3rd	12.1
Trifolium	3rd	9.0
Vicia	1st	23.7
Overall	**4th**	**4.0**

(1) Based on GENESYS information; Total accessions: 3,882,828 in 458 Institutes

Out of whole ICARDA's holdings ~45% are unique accessions and 78% phenotypically characterized



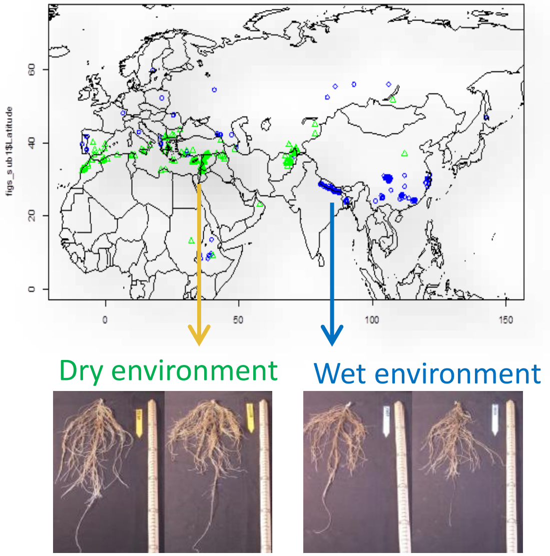
Composition by population type

Conservation Plant Genetic Resources and Agrobiodiversity

A wealth of novel genes at the fields…

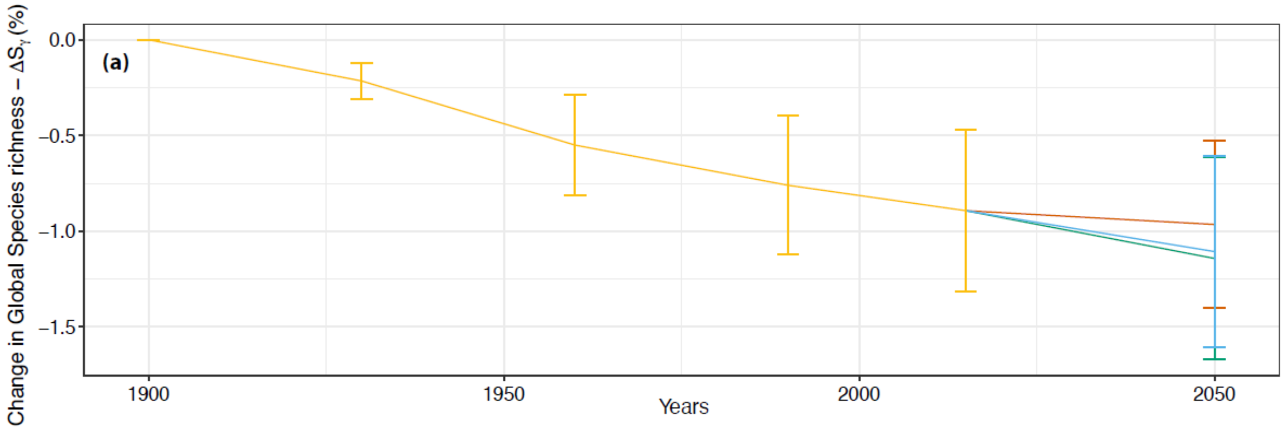
- ✓ Tackle epidemics of pests and diseases, owing to resistance genes (e.g. Hessian fly in wheat crop)
- ✓ Improve adaptation to climate change and related environmental adversities, due to the development of their specific adaptive traits under extreme/marginal environments)
- ✓ Meet consumers preferences for specific quality/culinary traits or even cultural traits (link to specific traditions)
- ✓ Surpass performance plateaus (e.g., Norin-10 changing the whole "architecture structure" of the wheat plant)

Ensure a better quality of life and they compose the raw material for global food security against any unprecedented adversity.

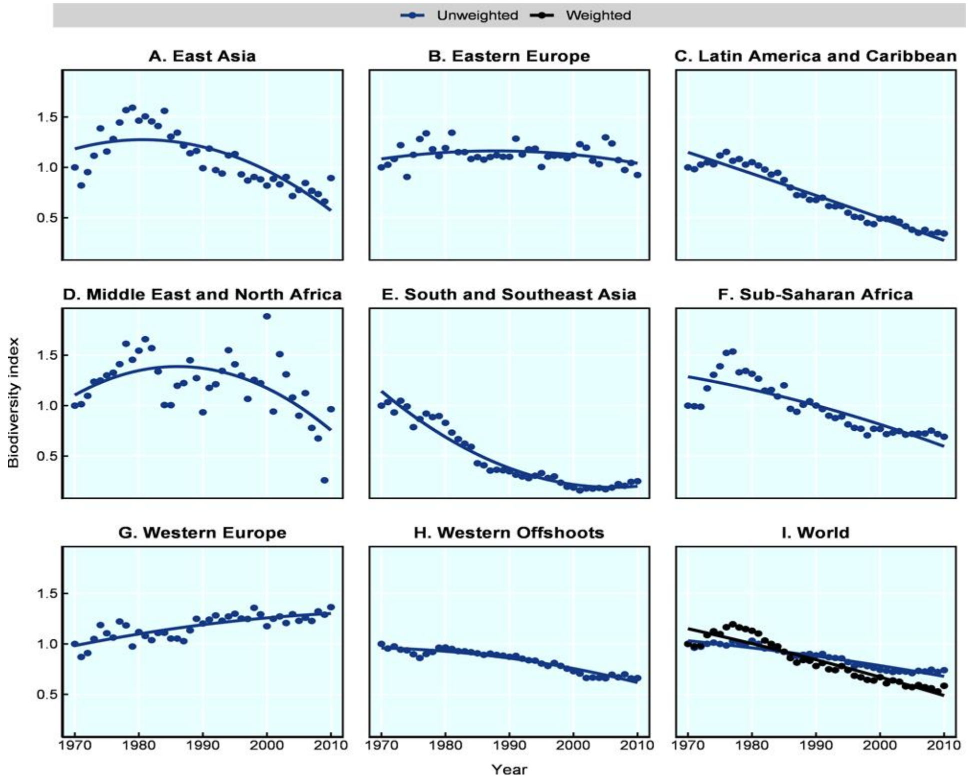


THANK YOU FOR YOUR KIND ATTENTION!

Trends on global species richness and biodiversity loss



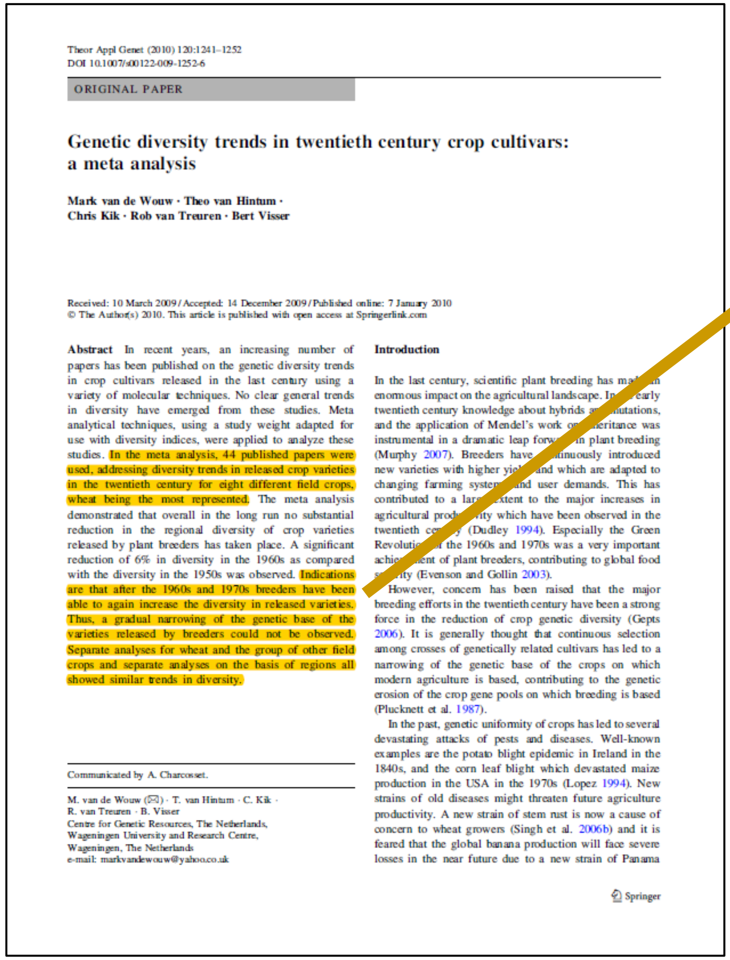
Proportional global species richness change (ΔSg) relative to 1900 from land-use change only (Pereira et al., 2020).



Biodiversity loss for different world regions based on the *Living Planet Index* methodology (van Goethem and van Zanden, 2021)

Our results reveal that local trends of abundance, richness and diversity differ among biogeoregions, realms and taxonomic groups, demonstrating that biodiversity changes at local scale are often complex and cannot be easily generalized (Pilotto et al., 2020)

Fortunately, existing varieties of most crops have quite a broad genetic base. Farmer-accepted, adapted varieties will continue to provide most of the genes that breeders need.



Theor Appl Genet (2010) 120:1241–1252
DOI 10.1007/s00122-009-1252-6

ORIGINAL PAPER

Genetic diversity trends in twentieth century crop cultivars: a meta analysis

Mark van de Wouw · Theo van Hintum · Chris Kik · Rob van Treuren · Bert Visser

Received: 10 March 2009 / Accepted: 14 December 2009 / Published online: 7 January 2010

Abstract In recent years, an increasing number of papers has been published on the genetic diversity trends in crop cultivars released in the last century using a variety of molecular techniques. No clear general trends in diversity have emerged from these studies. Meta analytical techniques, using a study weight adapted for use with diversity indices, were applied to analyze these studies. In the meta analysis, 44 published papers were used, addressing diversity trends in released crop varieties in the twentieth century for eight different field crops, wheat being the most represented. The meta analysis demonstrated that overall in the long run no substantial reduction in the regional diversity of crop varieties released by plant breeders has taken place. A significant reduction of 6% in diversity in the 1960s as compared with the diversity in the 1950s was observed. Indications are that after the 1960s and 1970s breeders have been able to again increase the diversity in released varieties. Thus, a gradual narrowing of the genetic base of the varieties released by breeders could not be observed. Separate analyses for wheat and the group of other field crops and separate analyses on the basis of regions all showed similar trends in diversity.

Communicated by A. Charcosset.

M. van de Wouw (✉) · T. van Hintum · C. Kik · R. van Treuren · B. Visser
Centre for Genetic Resources, The Netherlands, Wageningen University and Research Centre, Wageningen, The Netherlands
e-mail: markvandewouw@yahoo.co.uk

Introduction

In the last century, scientific plant breeding has made an enormous impact on the agricultural landscape. In the early twentieth century knowledge about hybrids and mutations, and the application of Mendel's work on inheritance was instrumental in a dramatic leap forward in plant breeding (Murphy 2007). Breeders have continuously introduced new varieties with higher yields and which are adapted to changing farming systems and user demands. This has contributed to a large extent to the major increases in agricultural productivity which have been observed in the twentieth century (Dudley 1994). Especially the Green Revolution of the 1960s and 1970s was a very important achievement of plant breeders, contributing to global food security (Evenson and Gollin 2003).

However, concern has been raised that the major breeding efforts in the twentieth century have been a strong force in the reduction of crop genetic diversity (Gepts 2006). It is generally thought that continuous selection among crosses of genetically related cultivars has led to a narrowing of the genetic base of the crops on which modern agriculture is based, contributing to the genetic erosion of the crop gene pools on which breeding is based (Plucknett et al. 1987).

In the past, genetic uniformity of crops has led to several devastating attacks of pests and diseases. Well-known examples are the potato blight epidemic in Ireland in the 1840s, and the corn leaf blight which devastated maize production in the USA in the 1970s (Lopez 1994). New strains of old diseases might threaten future agriculture productivity. A new strain of stem rust is now a cause of concern to wheat growers (Singh et al. 2006b) and it is feared that the global banana production will face severe losses in the near future due to a new strain of Panama

Indications are that after the 1960s and 1970s breeders have been able to again increase the diversity in released varieties. Thus, a gradual narrowing of the genetic base of the varieties released by breeders could not be observed.

van de Wouw et al. (2010) Theor Appl Genet, 120:1241–1252.