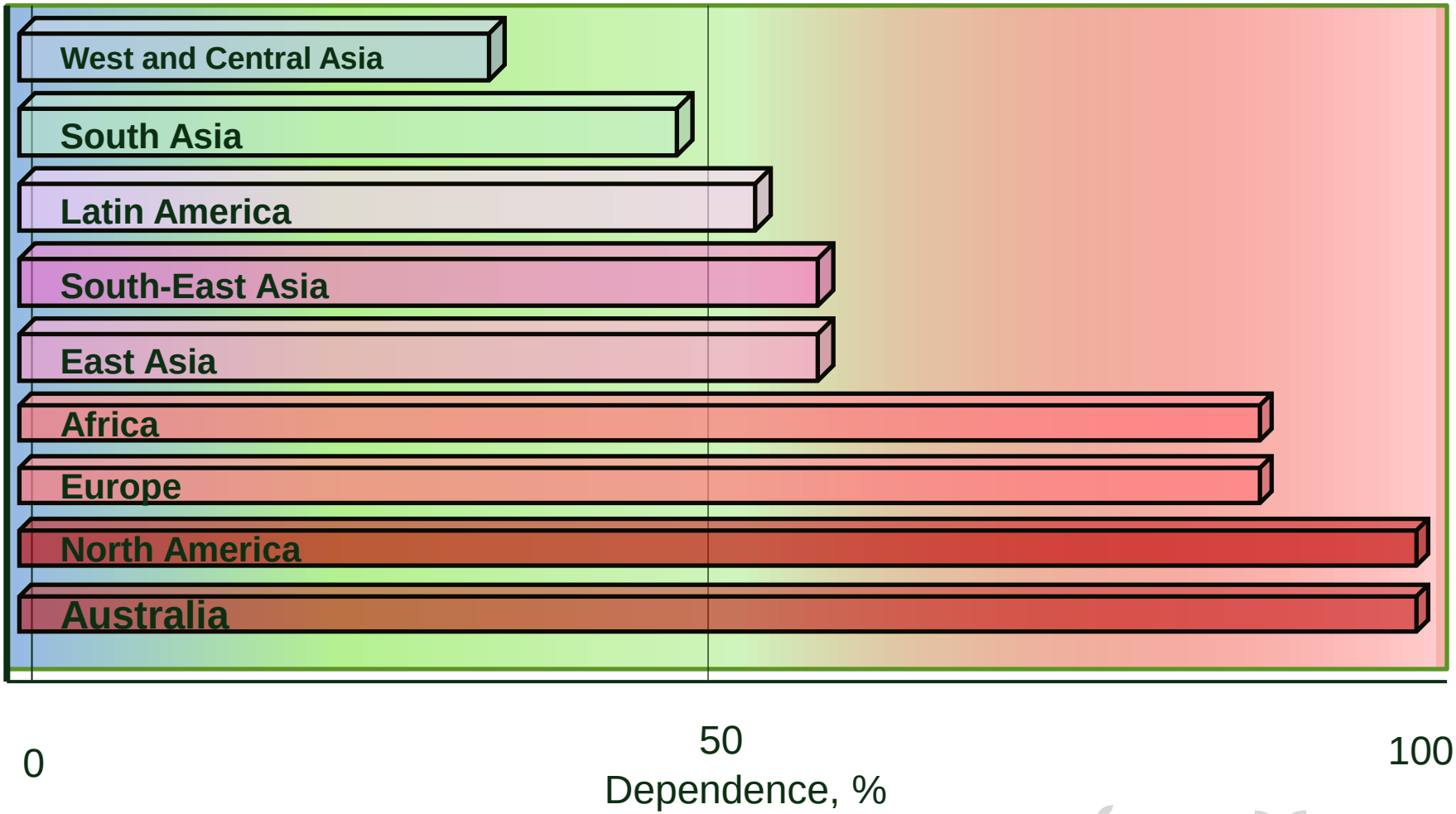
Vavilov's Collection of Cultivated Plants as a Strategic Basis for Food Security

Prof. Dzyubenko N.

Dependence of agricultural production based on the world's staple crops on the species introduced from other regions





Correlation between the formation of species and genetic resources



about 400 000 plant species grow on Earth

only 300 000 of them have been identified

30 000 of these species are edible

around 7 000 species have been domesticated

200 species have economic importance

30 species “feed the world

rice,
wheat,
potato

On 27 October 1894, the Bureau of Applied Botany was founded under the Scientific Committee at the Ministry of Agriculture and National Estate of the Russian Empire (now the Vavilov Research Institute of Plant Industry, or - VIR)

In 2014, VIR will celebrate its 120th birthday



“In 1906 the collection of the most important Russian barley accessions (257 samples as ears and 345 in grain) and the works on its comparative systematic research received the highest award (Diplome d`honneur) at the International Exhibition in Milan.

One cannot but be proud of this more than valuable barley collection gathered by the Bureau throughout our Empire. Now this collection is reckoned the third in the world”.

(A.I. Maltsev, 1908).

Scientific program of N.I. Vavilov



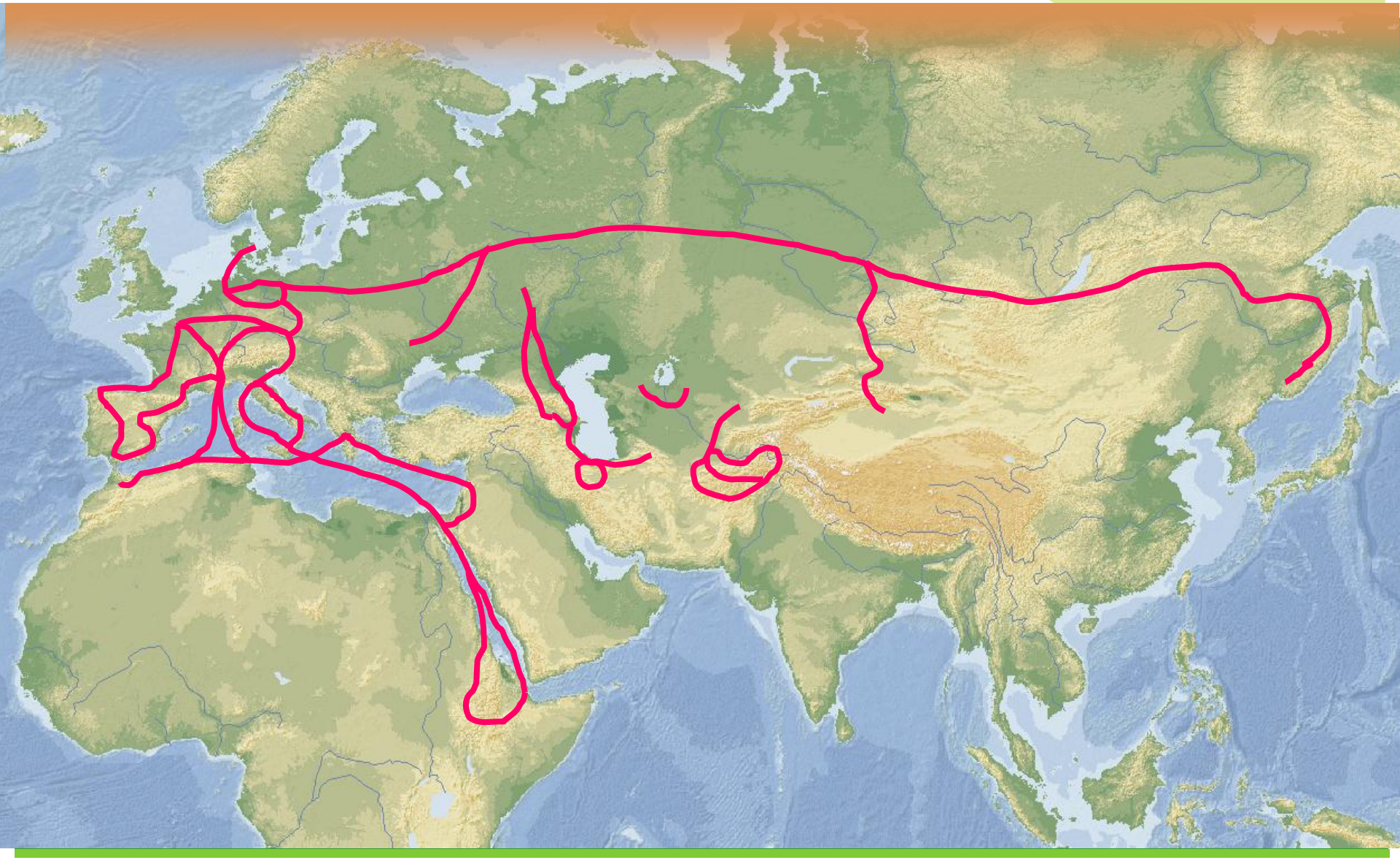
We can identify two stages in Vavilov' s programe development:

The first stage (1917-1929) is devoted to the collection and research of genetic resources of crop plants and their wild relatives of the world.

The second stage (1929-1940) envisages performing wide-scale scientific synthesis of knowledge and development of a theoretical basis of biology and breeding.

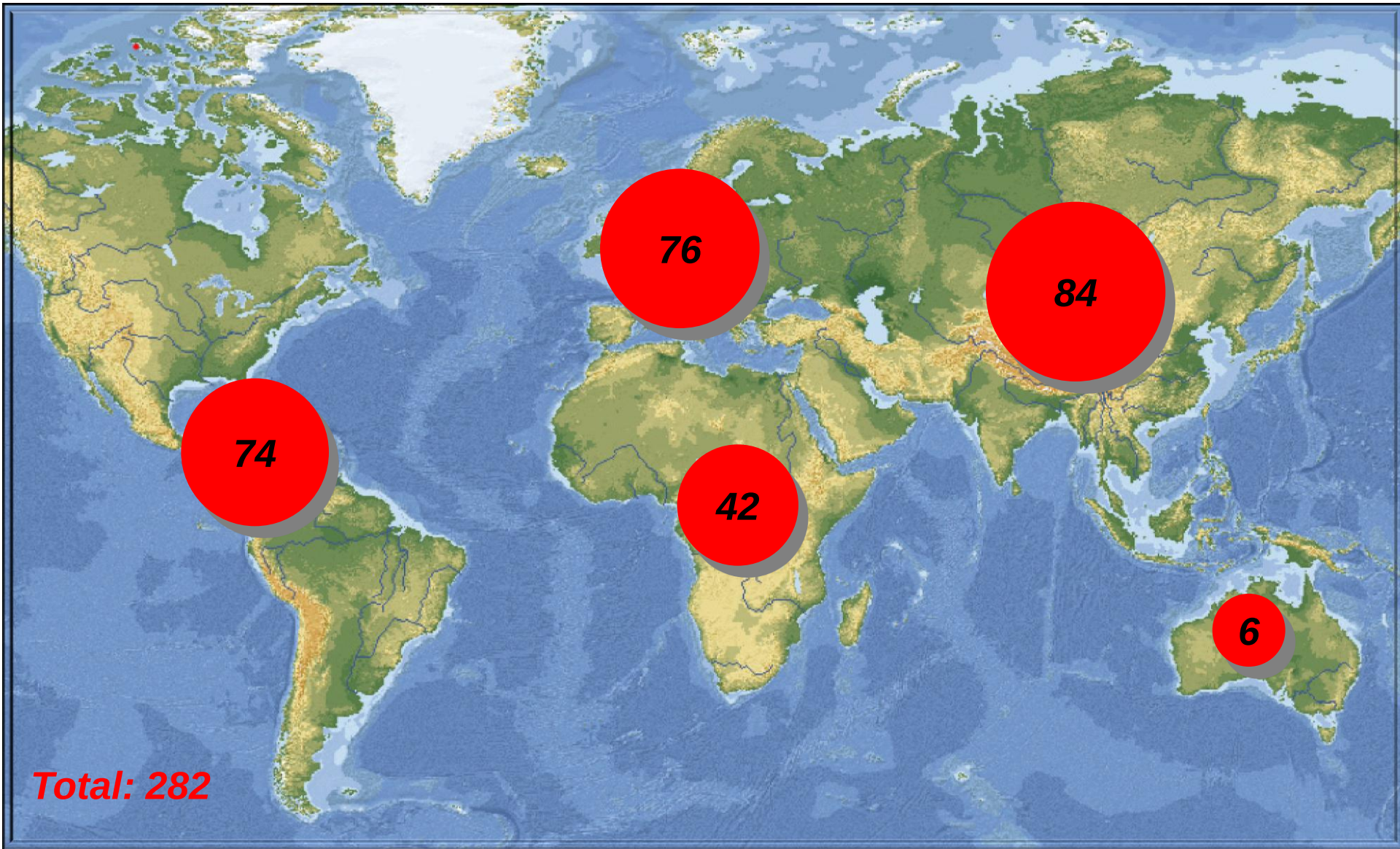
The routes of main collecting missions carried out by N. Vavilov in 1930, 1932 and 1933

The routes of main collecting missions by N. Vavilov (1916 -1940)



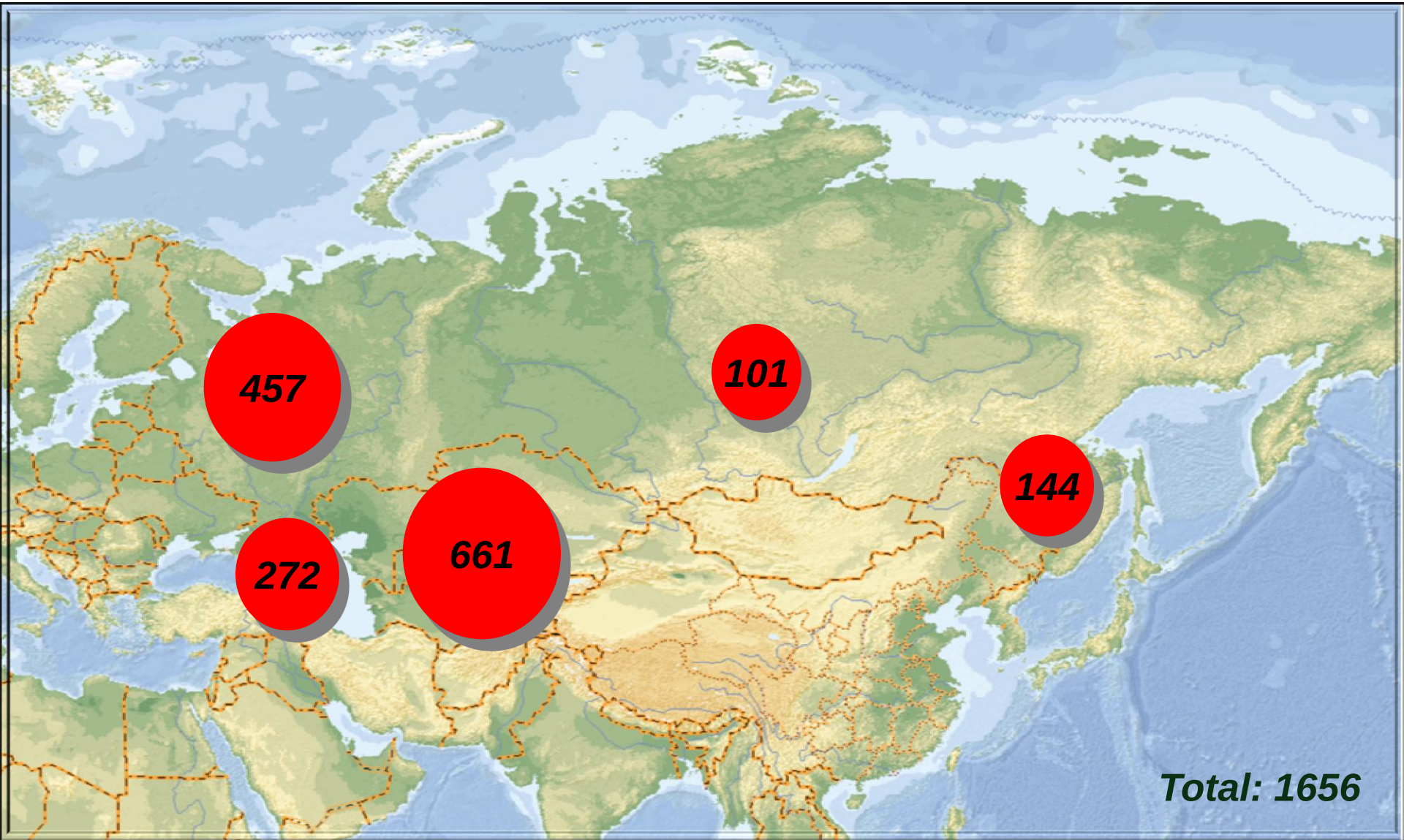
Geography of VIR collecting missions to foreign countries (1908-2013)





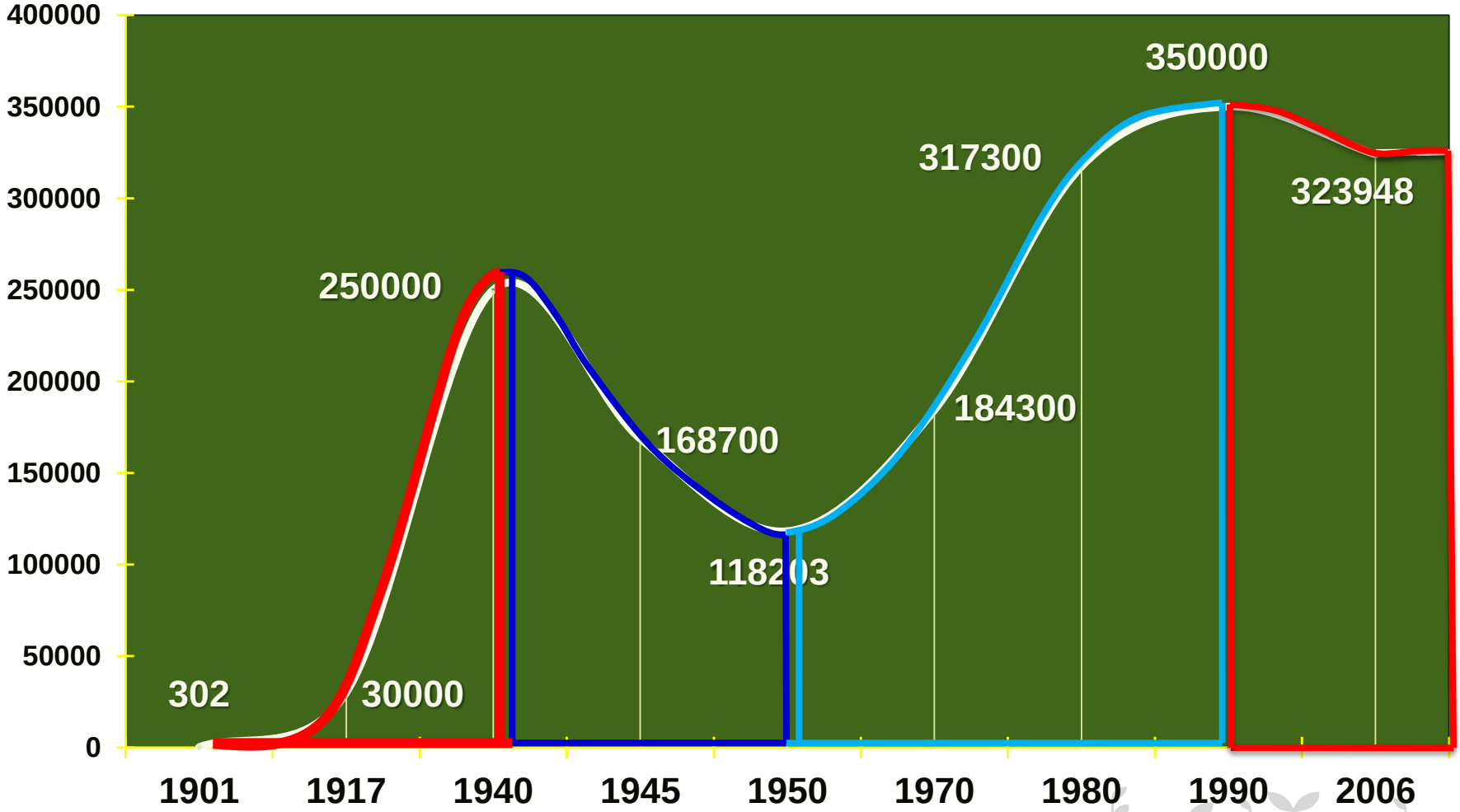
VIR's collecting missions over the territories of the ex-USSR (1908 – 2013)





VIR collections dynamics (1901–2012)







The United Nations Conference on Environment and Development in Rio de Janeiro, Brazil, 3 – 4 June 1992

3 important resolutions:

- **DECLARATION on Environment and Development (Rio Declaration)**
- **COMPREHENSIVE PLAN OF ACTION to be taken globally (Agenda 21)**
- **PRINCIPLES for Management, Conservation and Sustainable Development of All Types of Forests (Forest Principles)**

2 Conventions:

- **on Biological Diversity**
- **on Climate Change**

Convention on Biological Diversity (CBD)



The objectives of this Convention … are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources…

Article 1

A shift of the paradigm in nature management



Strategic vision of mankind has changed: now the world community proclaims the need to make transition from unrestrained exploitation to sustainable development.

Sustainable development **is a pattern of development that meets the needs of the present, but does not threaten the ability of future generation to meet their own needs (Agenda 21, Rio, 1992).**

Earth's genetic ability to maintain life must not be harmed: population levels of all life forms, wild and domesticated, should be at least sufficient for survival, and with this purpose essential habitats should be protected

(Conservation Strategy, 1980).

Shifting the paradigm in plant genetic resources (PGR) conservation



IT-1983

- PGR are the heritage of all mankind;
- free access to PGR;
- they have no price;
- conservation priority is ***ex situ.***

80 genebanks
1.5 million accessions

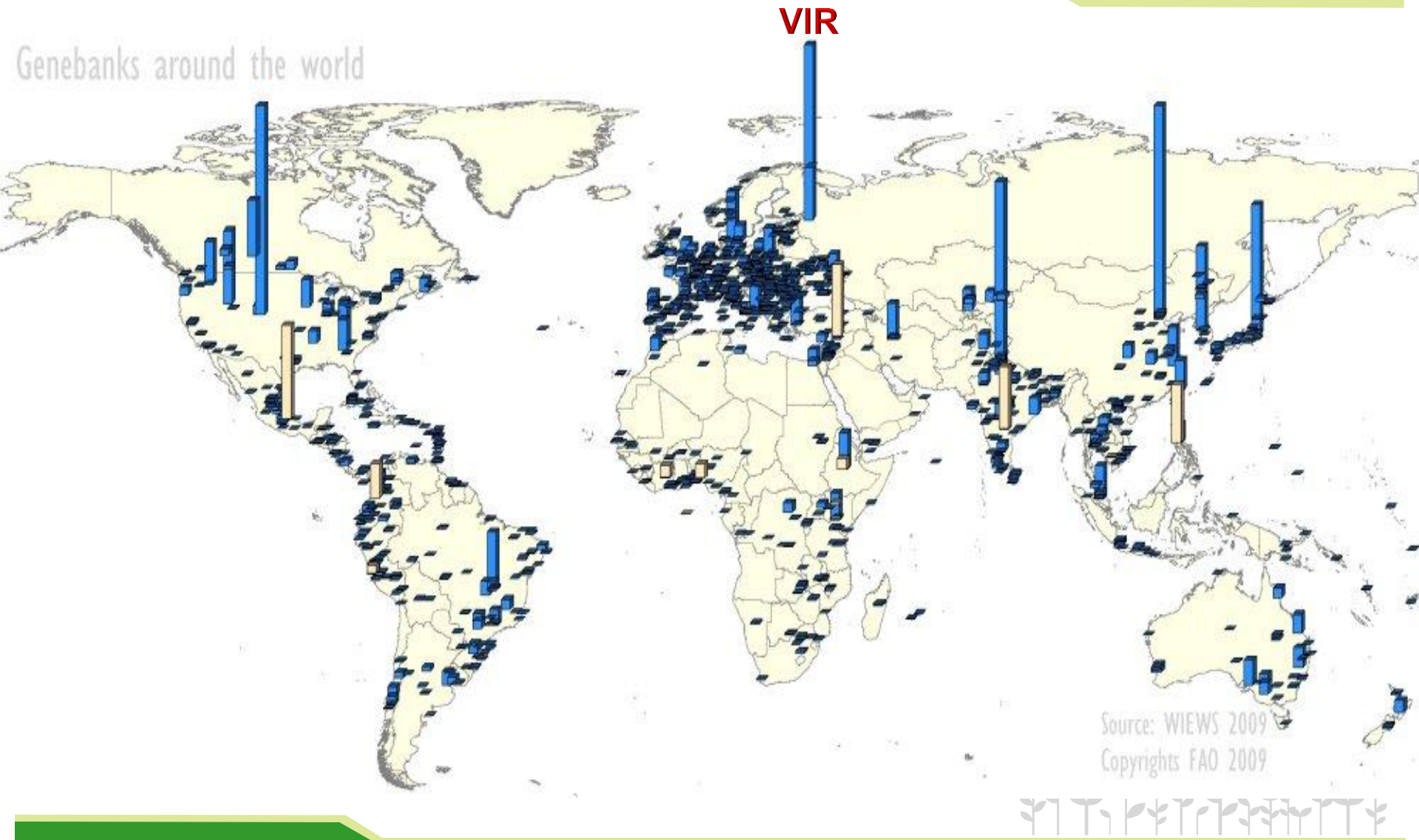
IT-2004

- PGR is sovereign property of a state;
- access to PGR is secured through bilateral agreements;
- patenting of PGR is possible;
- PGR is a potential source of profit;
- PGR conservation priorities are *ex situ* and *in situ*.

1750 genebanks,
7,03 million accessions

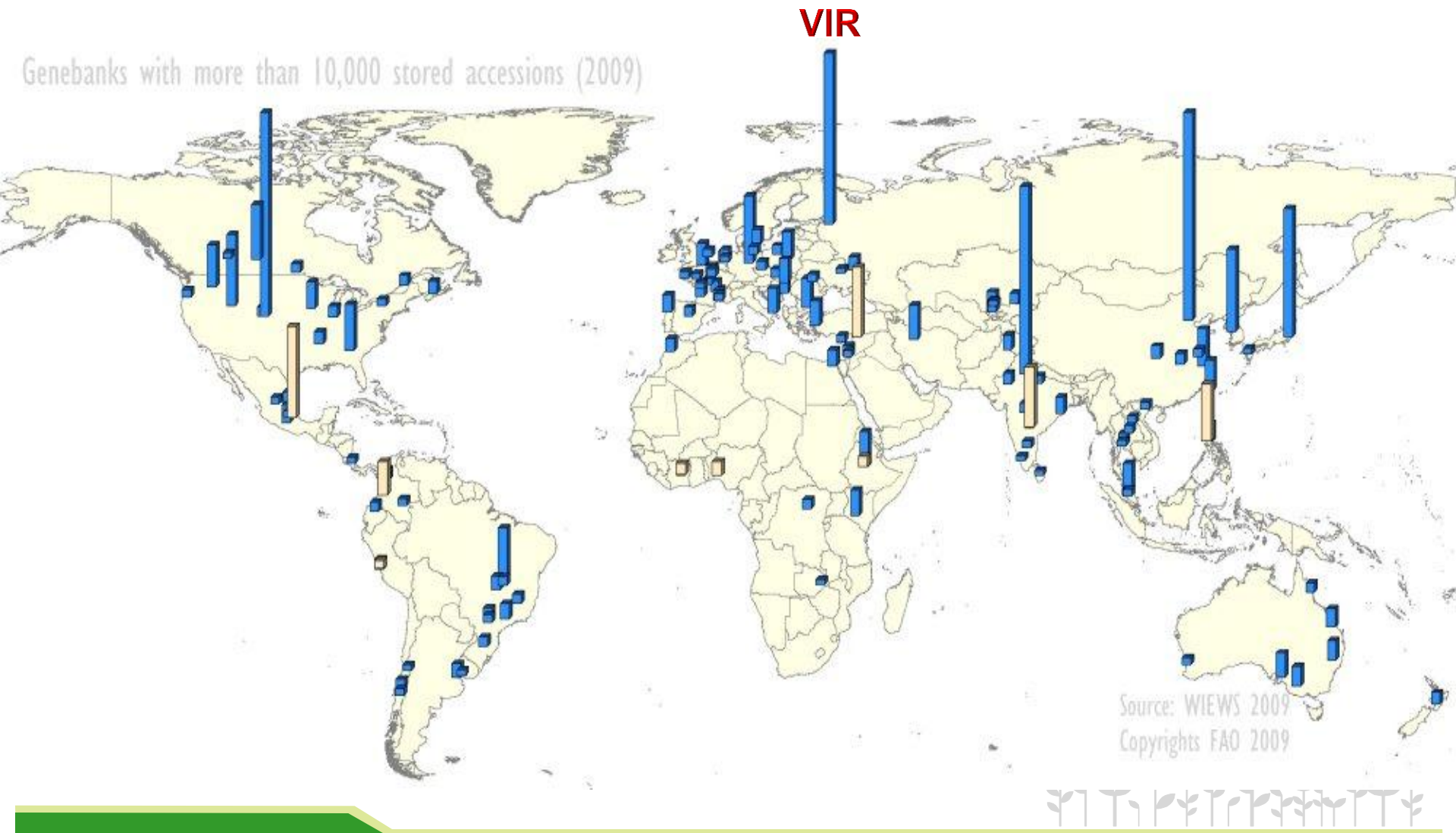
1750 genebanks of the world preserving 7.03 mln accessions (FAO, 2010)





130 genebanks of the world holding more than 10 000 accessions (FAO, 2010)





5 major genebanks of the world (FAO, 2010)



	COUNTRIES	ACCESSIONS
1.	USA	508994
2.	CHINA	391919
3.	INDIA	366333
4.	RUSSIA (VIR)	322238
5.	JAPAN	243463

COLLECTIONS OF THE CIS COUNTRIES



COUNTRY	ACCESSIONS
RUSSIA(VIR)	324 000 (54,1%)
UKRAINE	130 771 (21,7%)
KHAZAKSTAN	75 249 (9,2%)
USBEKISTON	70 186 (5,8%)
BELORUS	32 000 (5,3%)
GEORGIA	7 000 (1,1%)
ARMENIA	5 000 (0,9%)
MOLDOVA	5 000 (0,9%)
KIRGHISTAN	3 000 (0,5%)
TODJIKISTON	3 000 (0,5%)
TOTAL	**623 238 (100%)**

The world's *ex situ* collections of 10 staple crops (FAO, 2010)



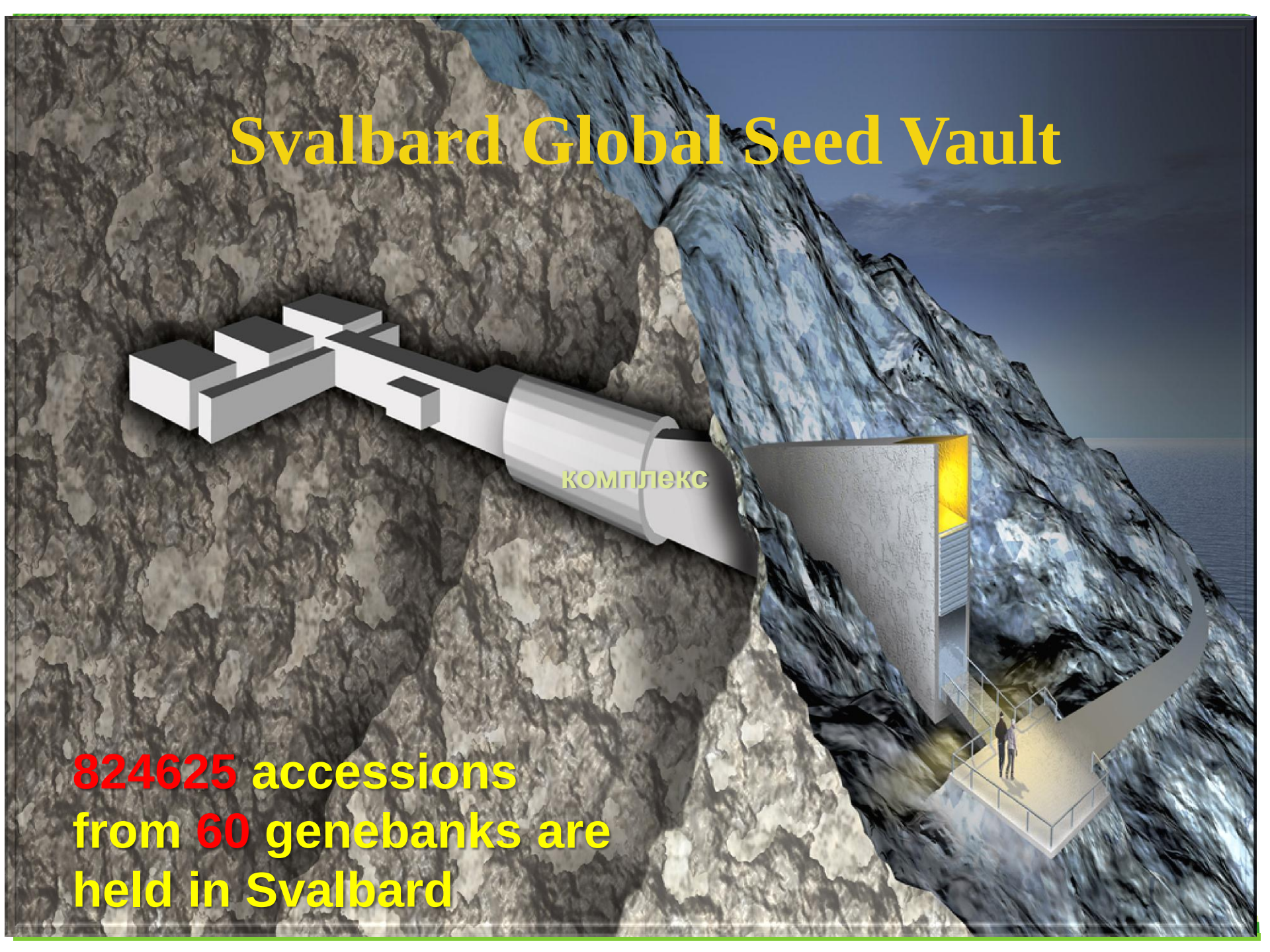
	CROPS	ACCESSIONS
1.	WHEAT	857940
2.	RICE	773847
3.	CORN	327931
4.	PHASEOLUS (beans)	262369
5.	SORGHUM	235711
6.	SOYA BEANS	229947
7.	OAT	148260
8.	PEANUT	128461
9.	POTATO	99253
10.	PEAS	93977

Structure of the world plant genetic diversity preserved *ex situ* (FAO, 2010)



GROUPS OF CROPS	% to total	Amount of accessions
CEREALS	45,3 %	3182020
LEGUME GRAINS	15,2 %	1070258
FORAGES	9,3 %	654529
VEGETABLES	7,2%	502817
FRUITS	6,0 %	423003
TUBEROUS	4,6 %	206002
INDUSTRIAL	5,9 %	416901
STRUCTURE OF COLLECTIONS		
CULTIVARS AND BREEDING LINES	38 %	
LOCAL VARIETIES AND LANDRACES	44%	
PWILD RELATIVES OF CULTIVATED PLANTS AND WEEDS	18 %	
GENEPOOL HOLDERS		
STATE/NATIONAL GENEBANKS		ABOUT 6500 000
INTERNATIONAL CENTERS/FAO		ABOUT 700 000
PRIVATE COLLECTIONS		ABOUT 105 000

Svalbard Global Seed Vault

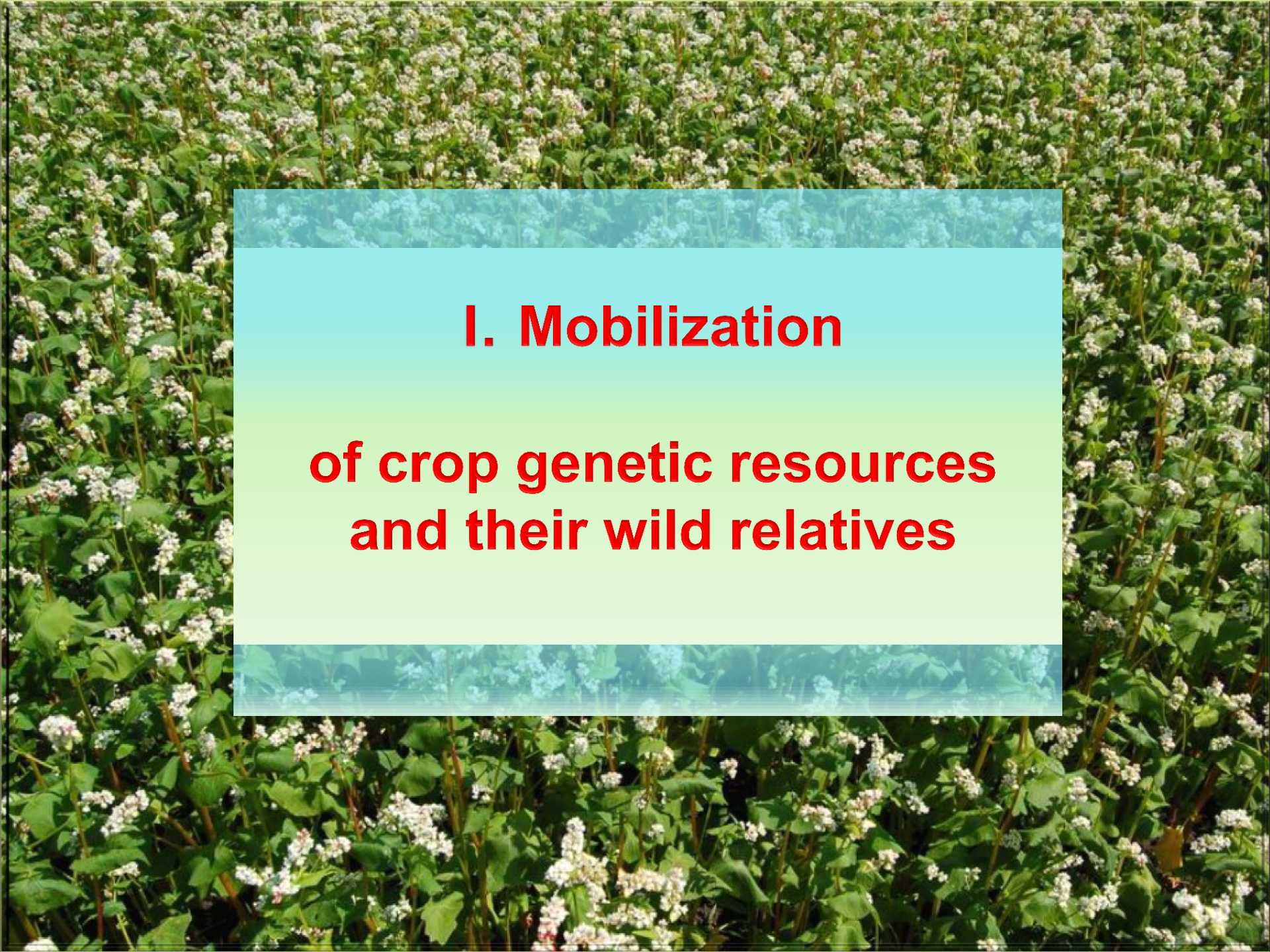


824625 accessions
from 60 genebanks are
held in Svalbard

Genetic diversity of the world's plant resources stored at the Vavilov Institute numbers 324955 accessions representing 64 families, 376 genera and 2169 species.

Genetic diversity of vegetatively propagated perennial plants is maintained in field collections numbering 29611 accessions.

VIR's herbarium collection numbers 324610 specimens.


I. Mobilization
of crop genetic resources
and their wild relatives

Mobilization of the world varietal resources, wide utilization of the global varietal diversity as source material for breeding practice is a number one priority.

N. I. VAVILOV

("Plant Resources on Earth and VIR's Work Towards Their Utilization", 1931 г.)

Structure of the contemporary categories of plant genetic resources



- Landraces and local varieties and populations.
- Modern breeding cultivars and hybrids of interest for breeders.
- Crop wild relatives (CWR).
- Weedy field populations.
- Rare botanical forms (mutants), genetic lines of various categories.
- Donors and genetic sources of economically valuable characters identified in the process of studying intraspecific and varietal diversity and/or obtained experimentally.

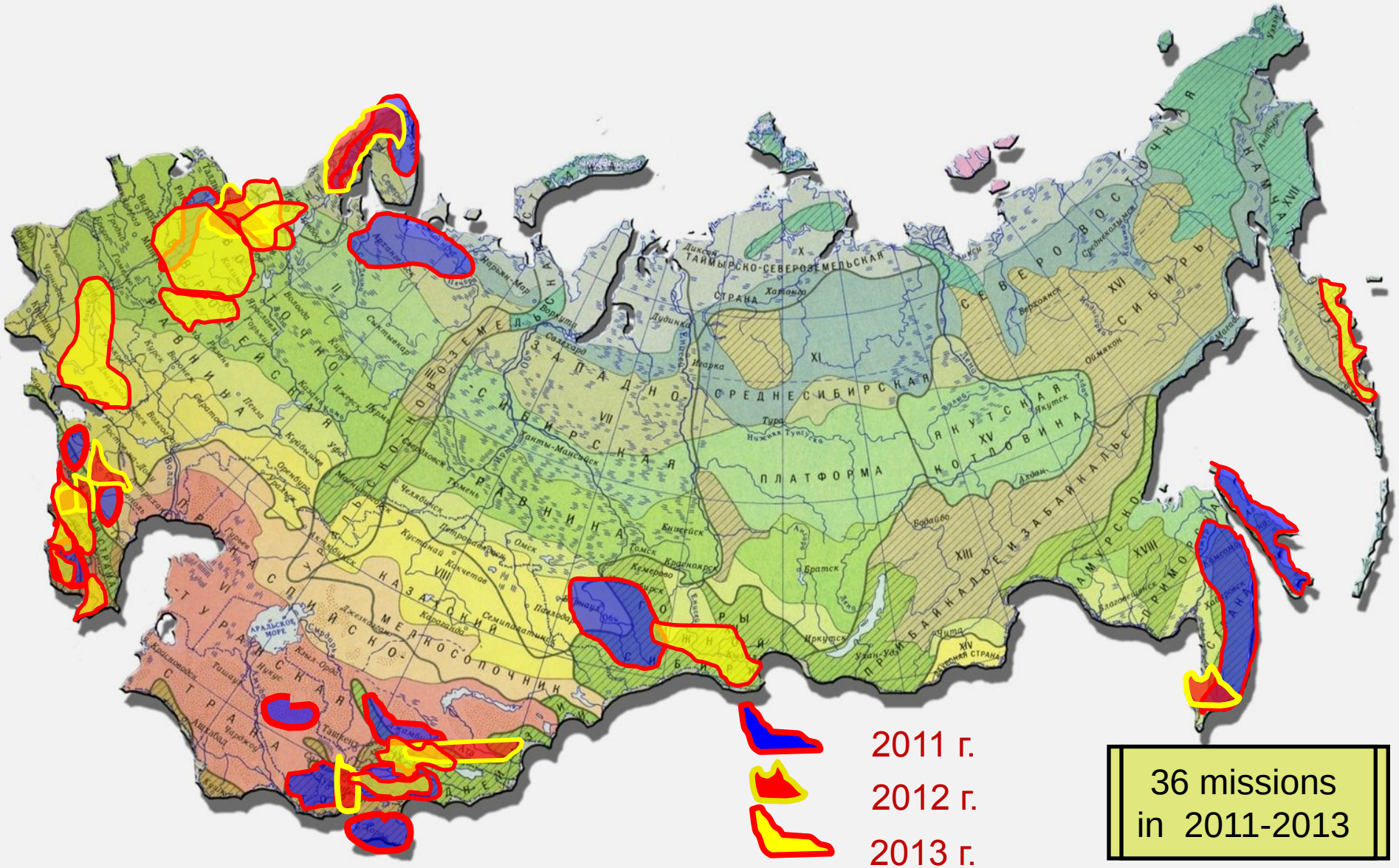
Modern algorithm of PGR mobilization consists of the following basic components:



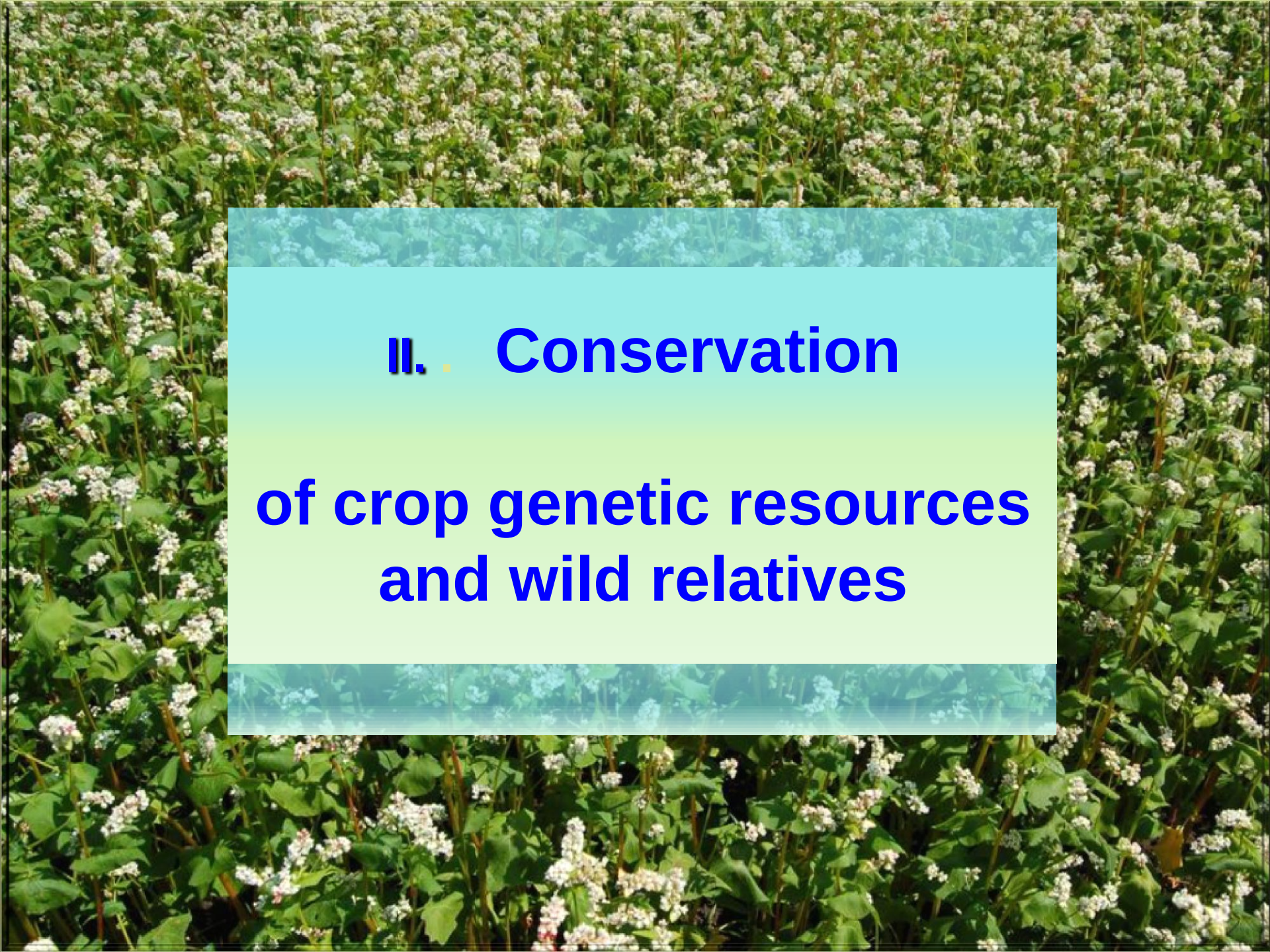
- analysis and evaluation of the global plant genetic diversity in nature and in genebanks;
- systematic inventorying (revision) and evaluation of the genetic diversity held in the genebank;
- identification of “gaps” in the collections held in the genebank;
- systematic analysis of national breeding programmes, identification and prognostication of the needs of these programmes as regards genetic source materials;
- assessment of genetic erosion and genetic vulnerability in the collection accessions of staple crops and their wild relatives.

Geographic coverage of the CIS territories by VIR's collecting missions in 2011-2013





36 missions
in 2011-2013


II. Conservation
of crop genetic resources
and wild relatives

Plant genetic resources conservation strategies



Static

Conservation of biodiversity components outside their natural habitats, that is in PGR collections (genebanks, botanic gardens, etc.)

EX SITU

Dynamic

Conservation of individual taxa within their agricultural and natural ecosystems

IN SITU

Plant genetic resources storage strategies



Controlled environments

- Low-temperature storage of seed collections (+4°C; –10°C).
- Cryogenic preservation (–196°C).
- ***in vitro*** preservation.

Non-controlled environments

• Maintenance of clone and other collections in the field.
• Maintenance of seed collections at room temperature.
• Storage of ultra-dry seeds.

Modern technology of ultra-dry seed storage



Key parameters:

- standard seed quality;
- seed moisture content of 0.5 – 1.5%;
- sealed packaging;
- monitoring of seed viability during storage.

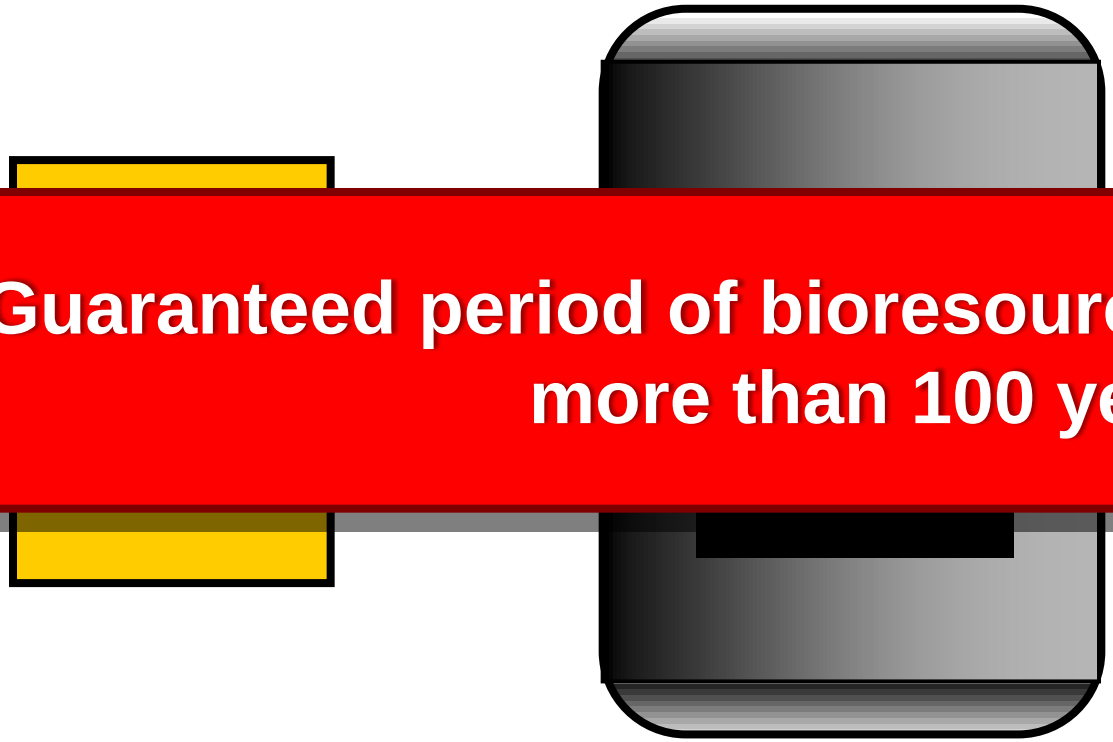
Guaranteed storage period at room temperature is more than 100 years.

Problems:

- not all plant species yield seed that retain viability after critical drying;
- complicated procedure of seed rehabilitation after long-term storage and obtaining viable plantlets.

Conveyor technology of PGR cryoconservation (-196°C)

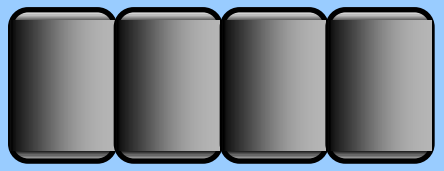




Monitoring of viability of

depend upon species traits

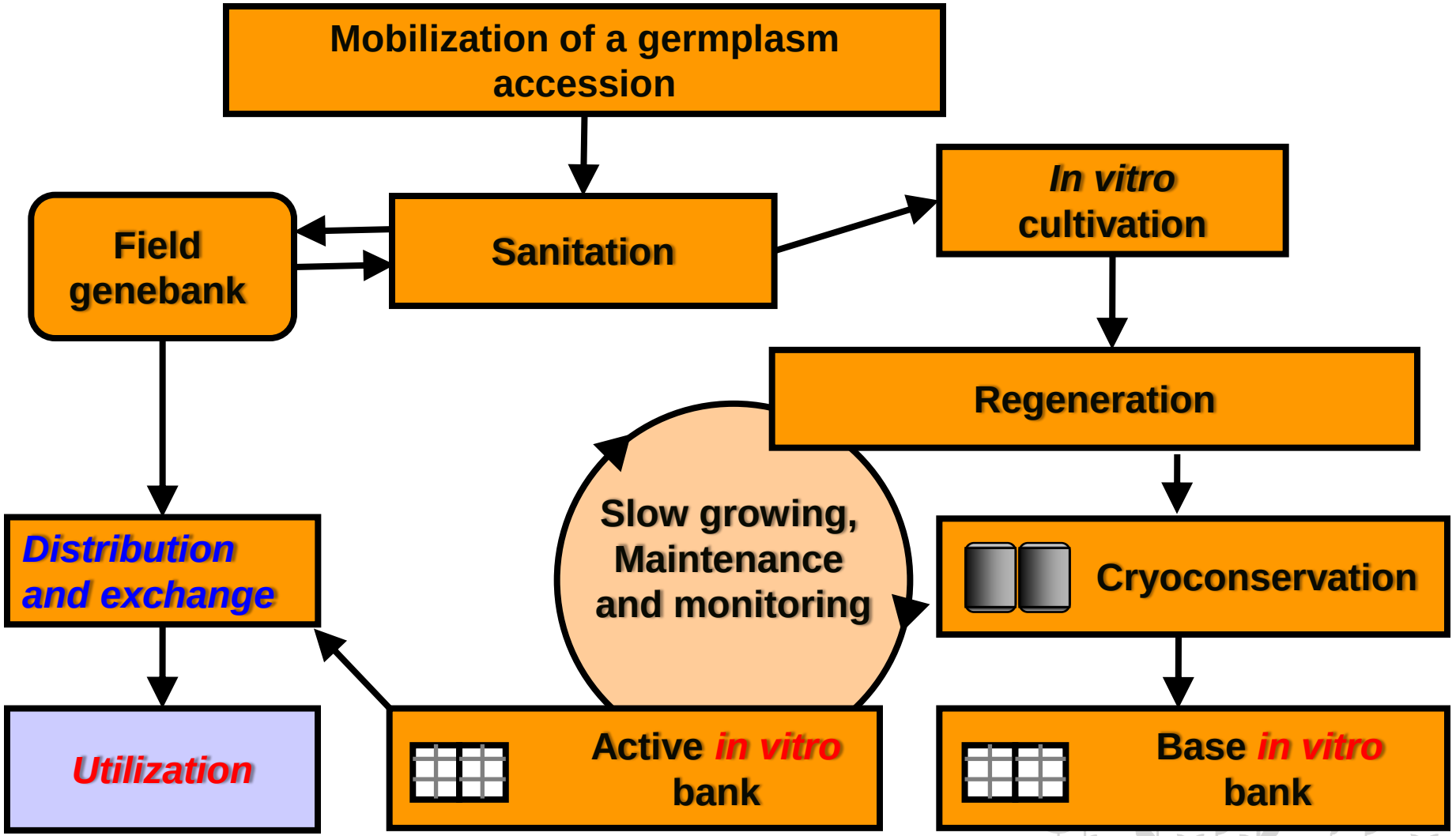
Guaranteed period of bioresources conservation is more than 100 years



Planned volume of VIR biocriocomplex– 40 – 80 thousansds volumes.

Conveyor technology of PGR *in vitro* storage





VIR's Genebank contains 572 902 accessions:



Of these, 48 659 accessions are placed for long-term storage, 80 365 for medium-term storage (-10°C), and 194 242 are maintained at +4°C.

There are 274123 accessions preserved at the Branch of VIR's Genebank. Of these, 191 184 are placed for long-term storage, 53 360 are safety duplicates, 13 746 are in operational storage, and 16 559 belong to other research institutions.

VIR's cryobank holds 437 pollen samples of fruit and berry plants.

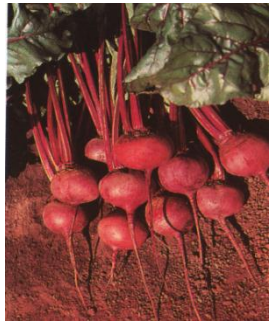
IV. Sustainable utilization

of crop genetic resources and wild relatives

Dynamics of germplasm dissemination from the VIR collections in 2007–2012



No	Crop	2007	2008	2009	2010	2011	2012	Total
1	Breeding centres (new accessions)	684	2909	2466	2330	840	2286	11515
2	Breeding centres (sources)	1260	1703	2243	2413	1960	2446	12025
3	Breeding centres (donors)	229	131	119	251	346	253	1329
4	Breeding centres (collection)	3455	4806	4069	4877	4670	3070	24947
5	Other research centres	6757	4787	5363	4148	3757	2255	27067
6	North-West		1835	1621	1006	1281	1160	5444
7	SUBTOTAL for Russia:	12385	16171	15881	15025	12854	11470	83786
8	Foreign genebanks and research centres	6741	2531	8225	7070	4202	2355	31124
	TOTAL:	**19126**	**21913**	**24106**	**22095**	17056	13825	



In 2006-2013 VIR submitted 136 cultivars to the State Variety Testing Committee;

91 cultivars have been listed with the State Register of Breeding Achievements of the Russian Federation;

70 authorship certificates and 55 patents have been issued.

Cultivars in the State register of breeding achievements (data valid for 03/02/2014)



VIR CULTIVARS

96 SPECIES

476 VARIETIES

TOTAL CULTIVARS IN RUSSIA

507 SPECIES

16 111 VARIETIES

(2310 of them of foreign origin)

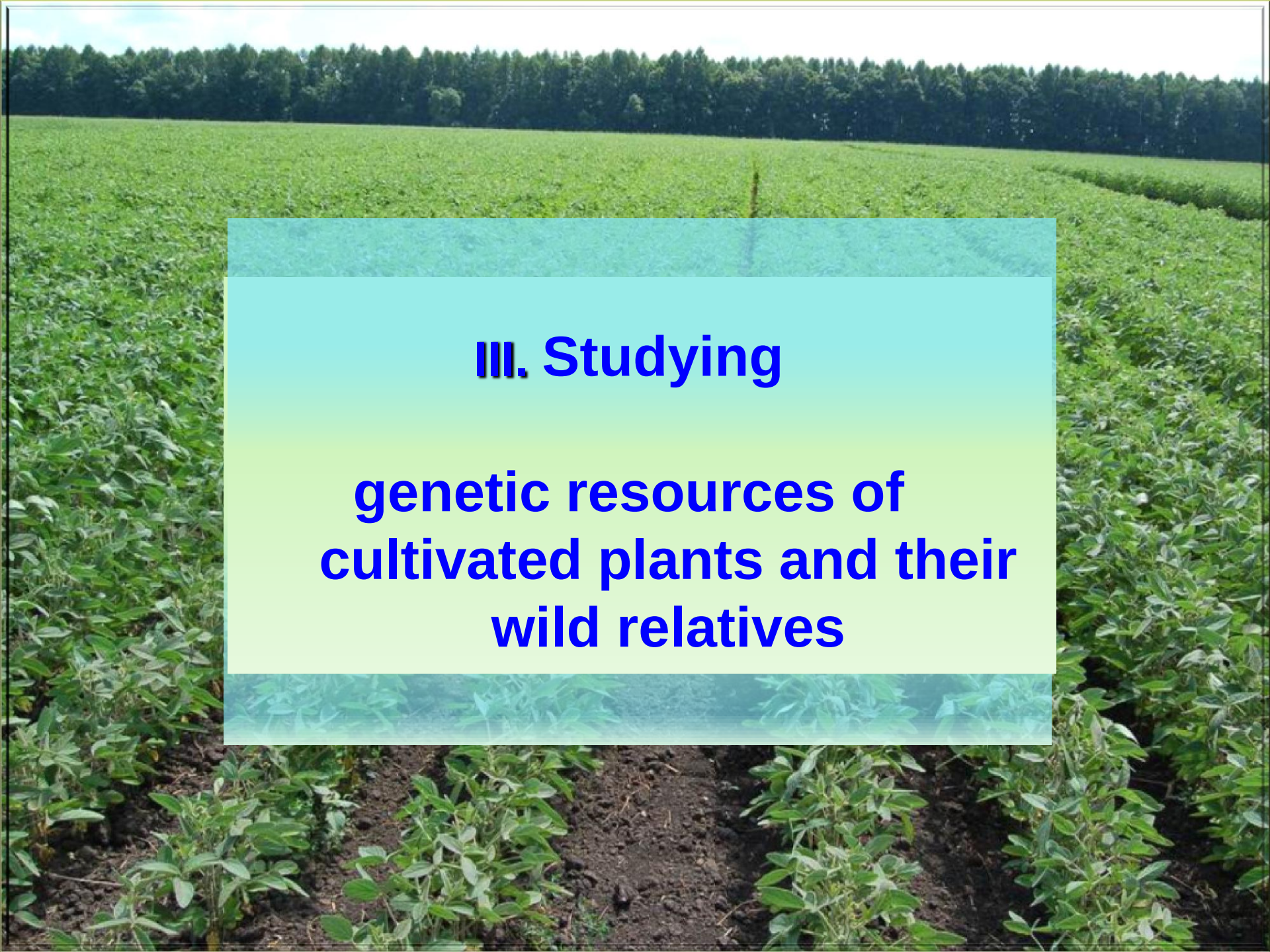
“It is better to display excessive concern now, than to destroy all that has been created by nature for thousands and millions of years ...”

N. I. VAVILOV


Thank you for attention!



In February 1932, N. Vavilov estimated composition of the institute's collections as follows: "VIR possesses an exceptional material; suffice to say that it has over 28 thousand wheat accessions, 13 thousand accessions of barley, 8 thousand of oats, 22 thousand of grain legumes, 15 thousand of maize, sorghum and *Panicum*-related crops, 6 thousand of oil crops; altogether it has over 150 thousand accessions".



III. Studying

genetic resources of cultivated plants and their wild relatives

The Vavilov Institute has developed and successfully applied:



- a system of complex evaluation of the collected diversity with field and laboratory methods;

- a basic scheme of targeted search for (and/or development of) efficient sources and donors of plant characters valuable for breeding.

Scheme of search, development and utilization of donors of characters valuable for plant breeding (A.F. Merezhko, 2005)



VIR

1 Setting up character-oriented collections of intraspecific diversity

2 Identifying genetic differences between source accessions

3 Studying genetic control over a plant character on the level of species

4 Forming genetic collections according to plant characters

5 Identifying donors of valuable characters in the collection or their development

6 Distributing donors to breeding centres

BREEDING CENTRES

7 Formulating the breeding objective

8 Choosing a plant variety or a line for improvement

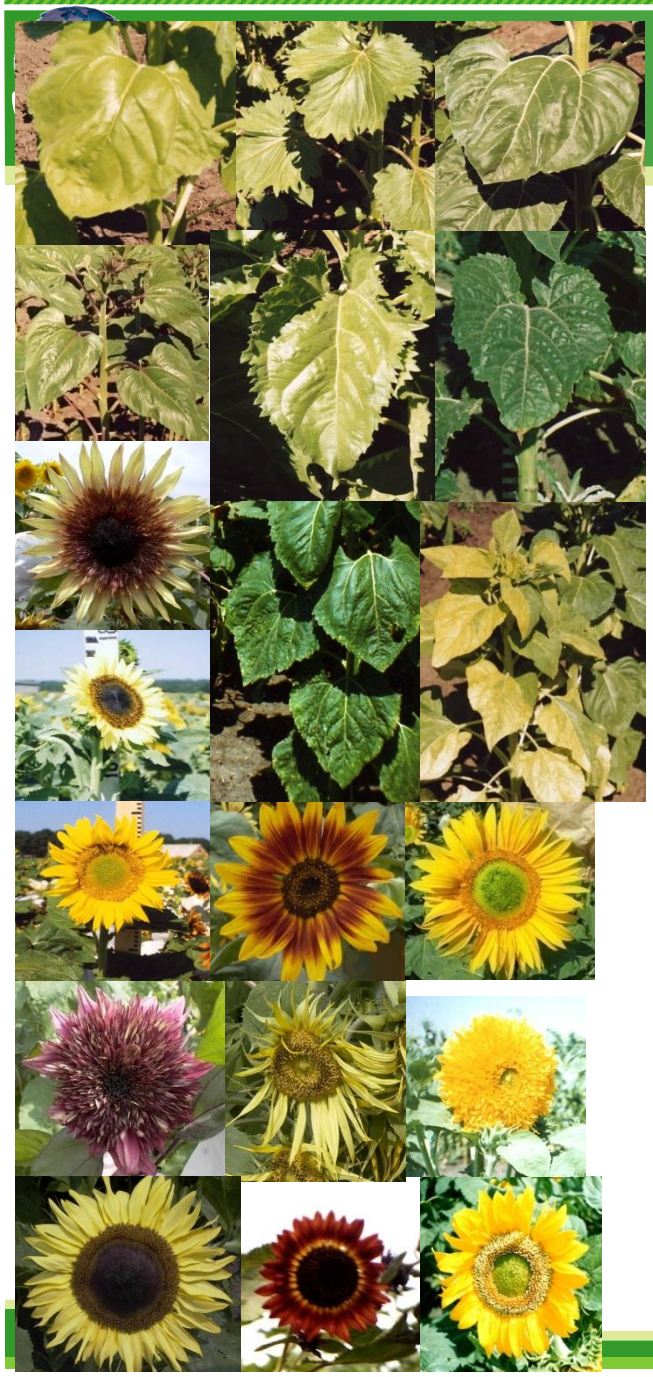
9 Selecting donors

10 Breeding new improved cultivars

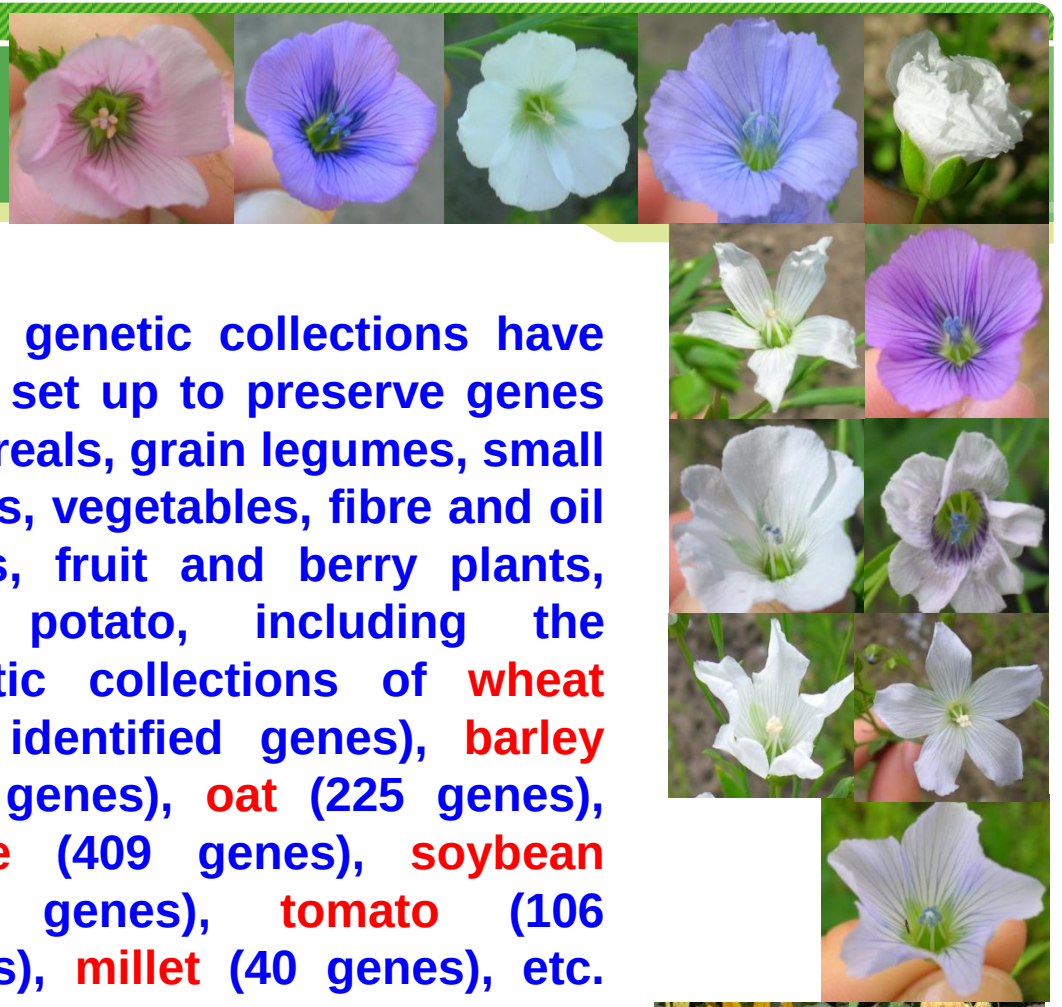
In 2013



14 492 accessions have been studied both in the field and in laboratory at the Institute and its experiment stations, and 5175 of these accessions underwent complex examination. As a result, 10 donors and 1035 sources of commercially valuable traits have been developed or identified.



20 genetic collections have been set up to preserve genes of cereals, grain legumes, small grains, vegetables, fibre and oil crops, fruit and berry plants, and potato, including the genetic collections of wheat (400 identified genes), barley (100 genes), oat (225 genes), maize (409 genes), soybean (200 genes), tomato (106 genes), millet (40 genes), etc. Our experts succeeded to produce meiotic mutants of maize and marked lines of sunflower for research and breeding purposes.



A new trend in potato breeding

VIR develops a new trend in potato breeding – development of dietary cultivars, including those with pulp coloured by anthocyanins – flavonoids with strong antioxidant properties.

One of the world's largest collections of South American cultivated potato species at VIR consists of approximately 3300 accessions belonging to 8 species.

Research on the collection of cultivated potato species carried out by VIR resulted in identifying source material for the new trend in potato breeding.