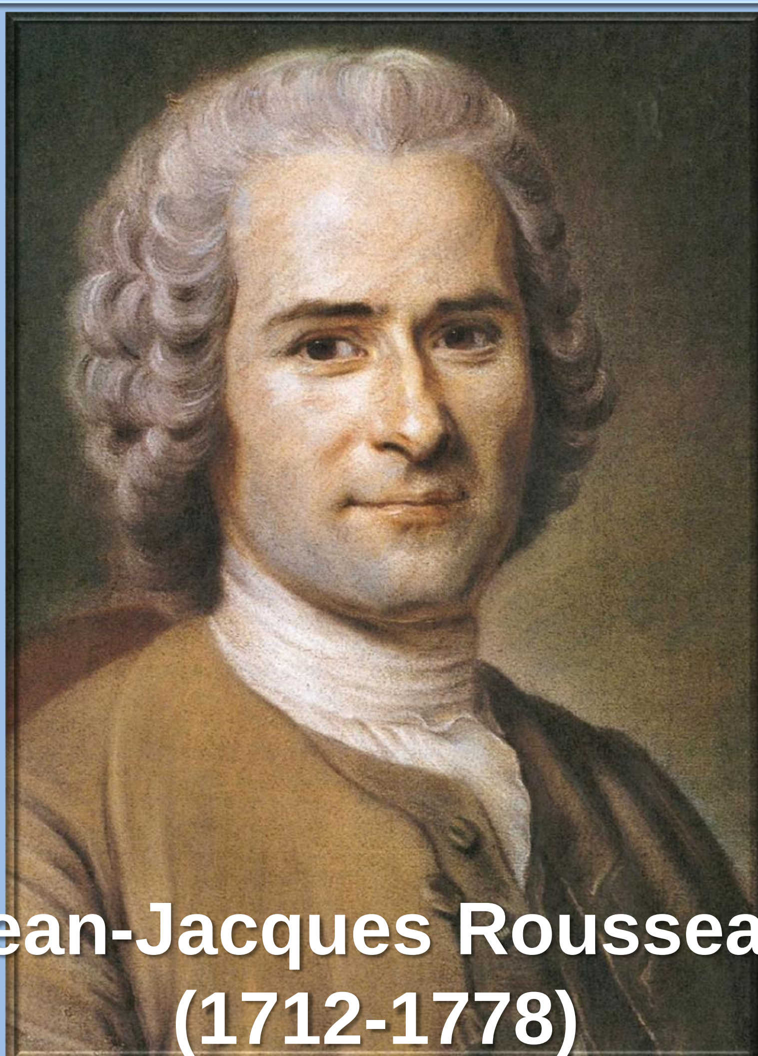
VIR

Vavilov's Collection of Cultivated Plants: Strategy and Problems

Prof. Dzyubenko N.



Jean-Jacques Rousseau
(1712-1778)

“The only means to keep a state independent from anybody is agriculture. Should you even possess all the riches of the world, if you have nothing to eat you will depend on others… Trade creates wealth, but agriculture provides freedom”.

How to Feed the World in 2050

Executive Summary

1. **Introduction**
2. **Outlook for food security towards 2050**
   (1) The changing socio-economic environment
   (2)The natural resource base to 2050 – will there be enough land, water and genetic diversity to meet demands?
   (3) Potential for food security
3. **Prerequisites for global food security**
   (1) Enhancing investment in sustainable agricultural production capacity and rural development
   (2) Promoting technology change and productivity growth
   (3) Trade, markets and support to farmers
4. **The risks and challenges**
   (1) Hunger amidst adequate overall supplies
   (2) Climate Change
   (3) Biofuels
5. **Mobilizing political will and building institutions**

(2)The natural resource base to 2050 – will there be enough land, water and genetic diversity to meet demands?

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

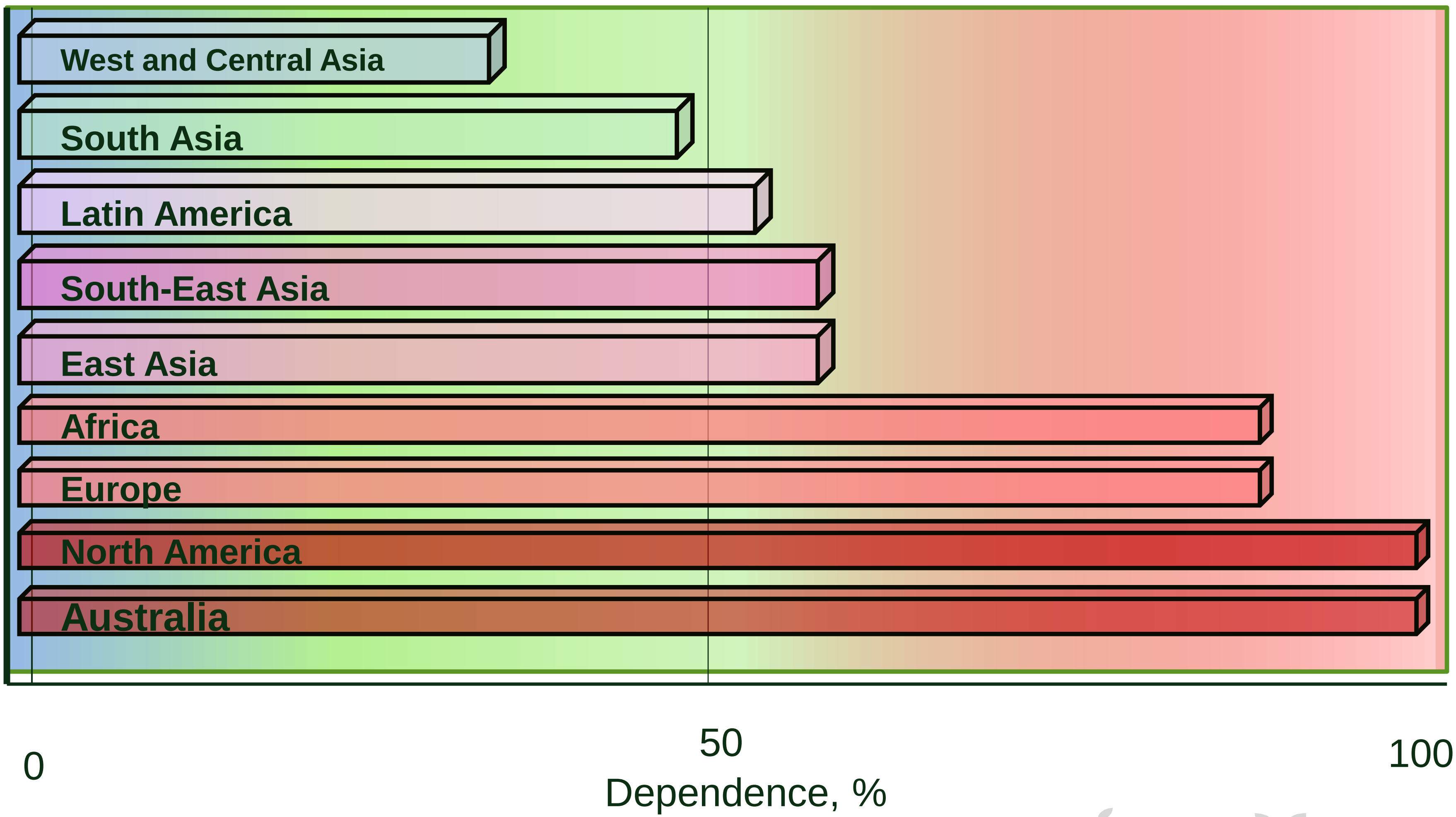
around 7 000 species have been domesticated

200 species have economic importance

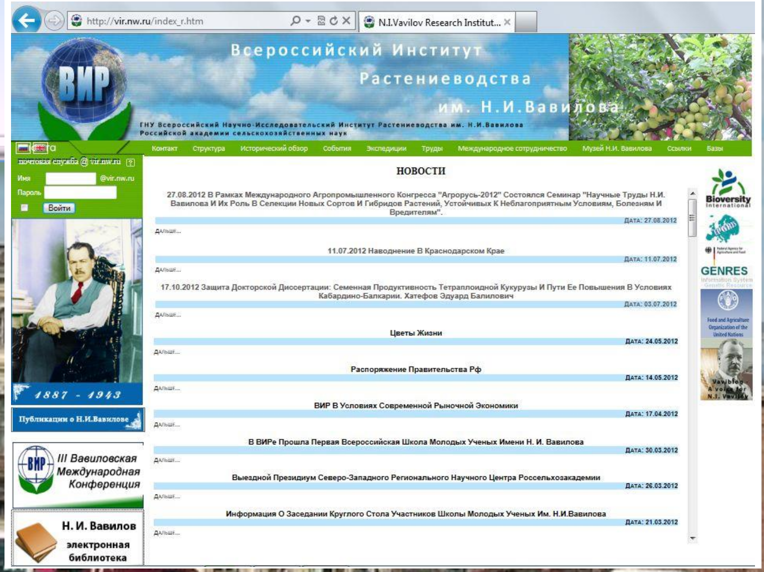
30 species “feed the world

rice,
wheat,
potato

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



On 27 October 1894, the **Bureau of Applied Botany** was founded under the Scientific Committee at the Ministry of State Property of the Russian Empire. The Bureau has gradually evolved into the Vavilov Research Institute of Plant Industry, or - **VIR**)



In 2017 VIR will celebrate the 130th anniversary of Nikolay Vavilov's 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".

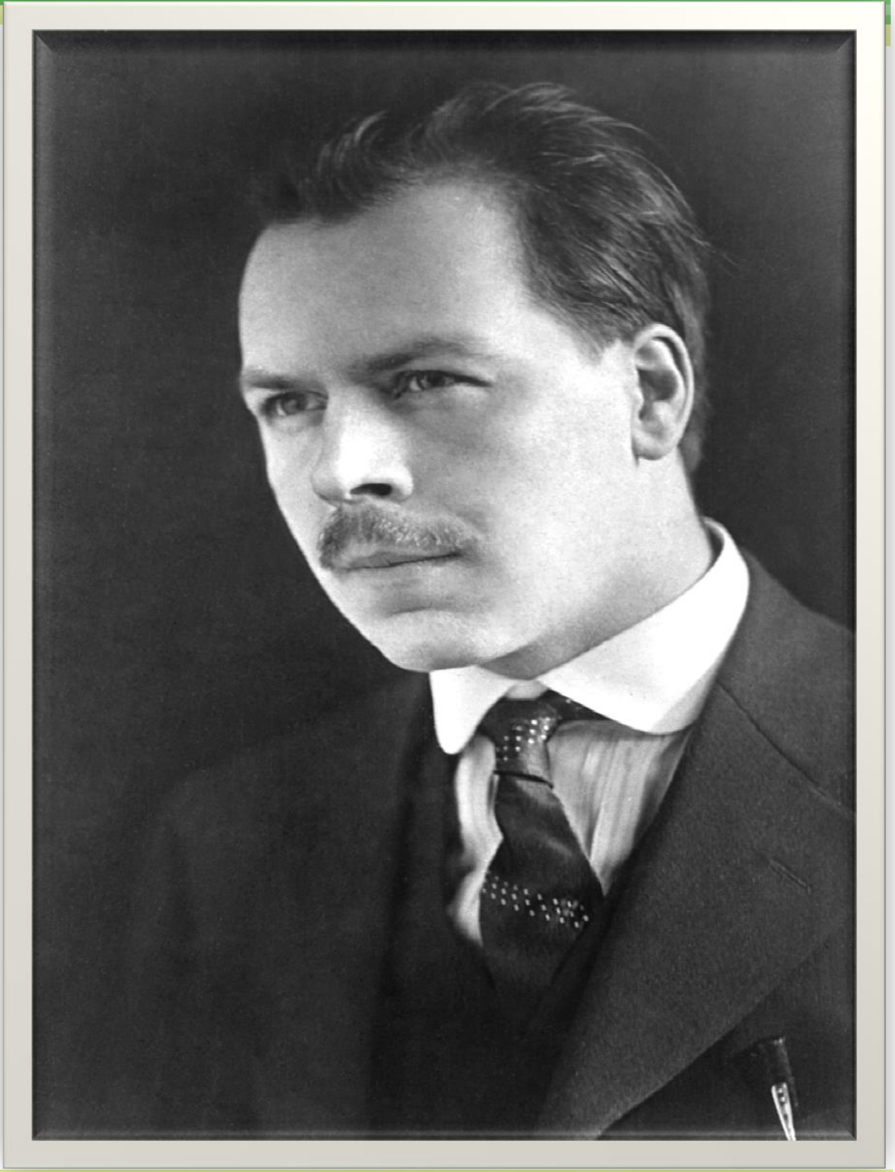
(A.I. Maltsev, 1908).

Scientific program of N.I. Vavilov

We can identify two stages in Vavilov’ s program development:

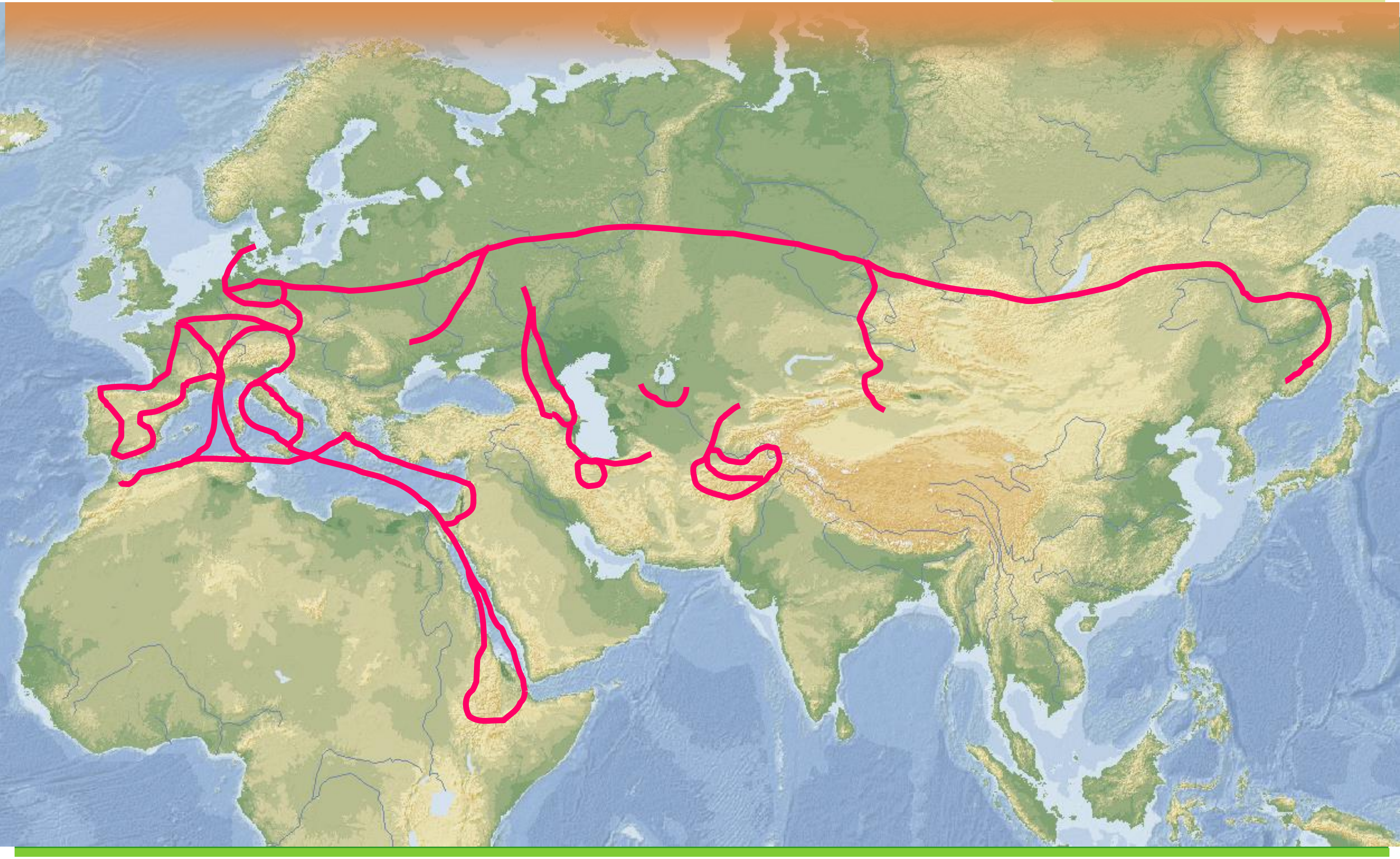
The first stage (1917-1929) is devoted to the collection and research of genetic resources of crop plants and their wild relatives of the world.

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

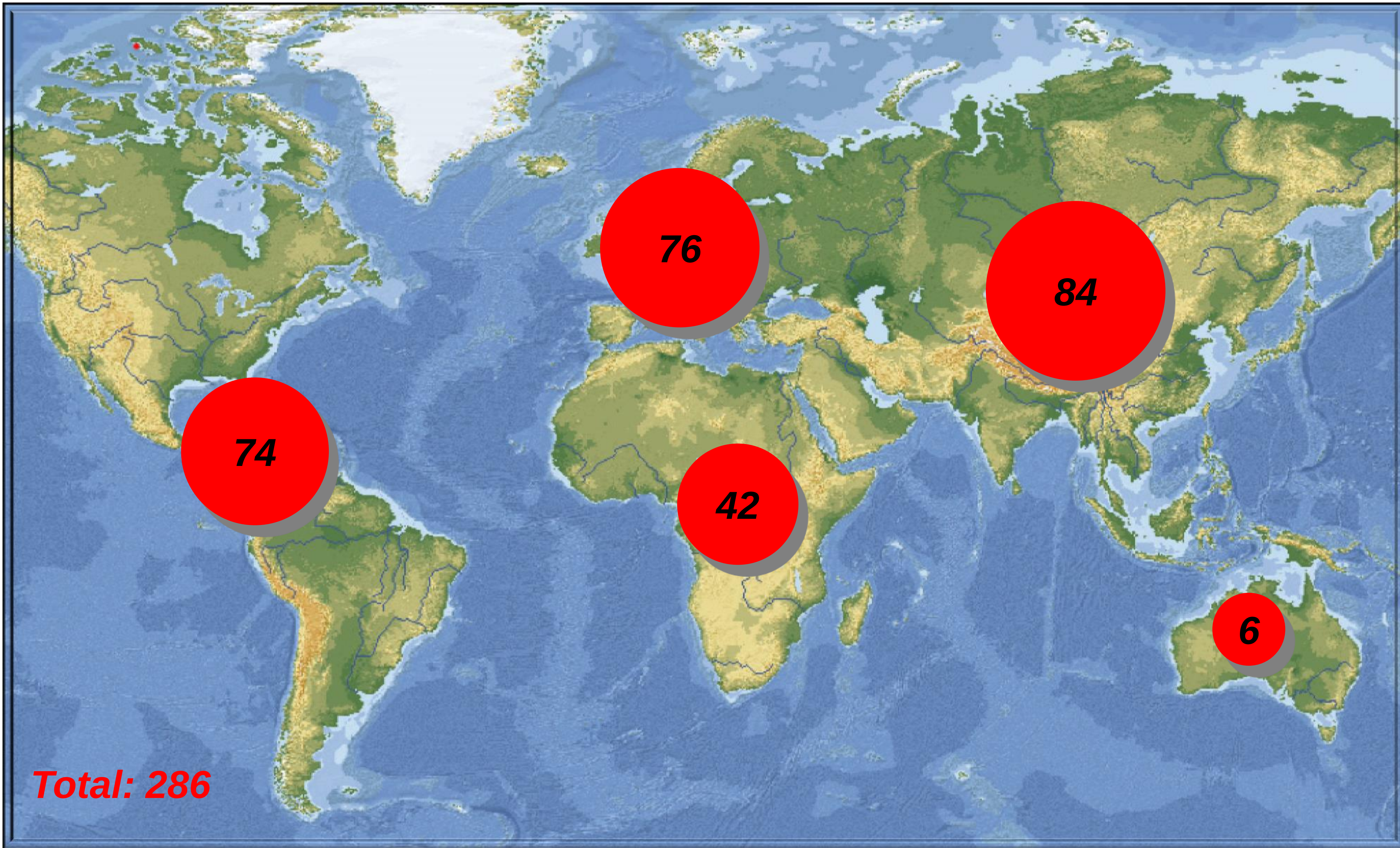


The routes of main collecting missions carried out by N. Vavilov in 1930, 1932 and 1933

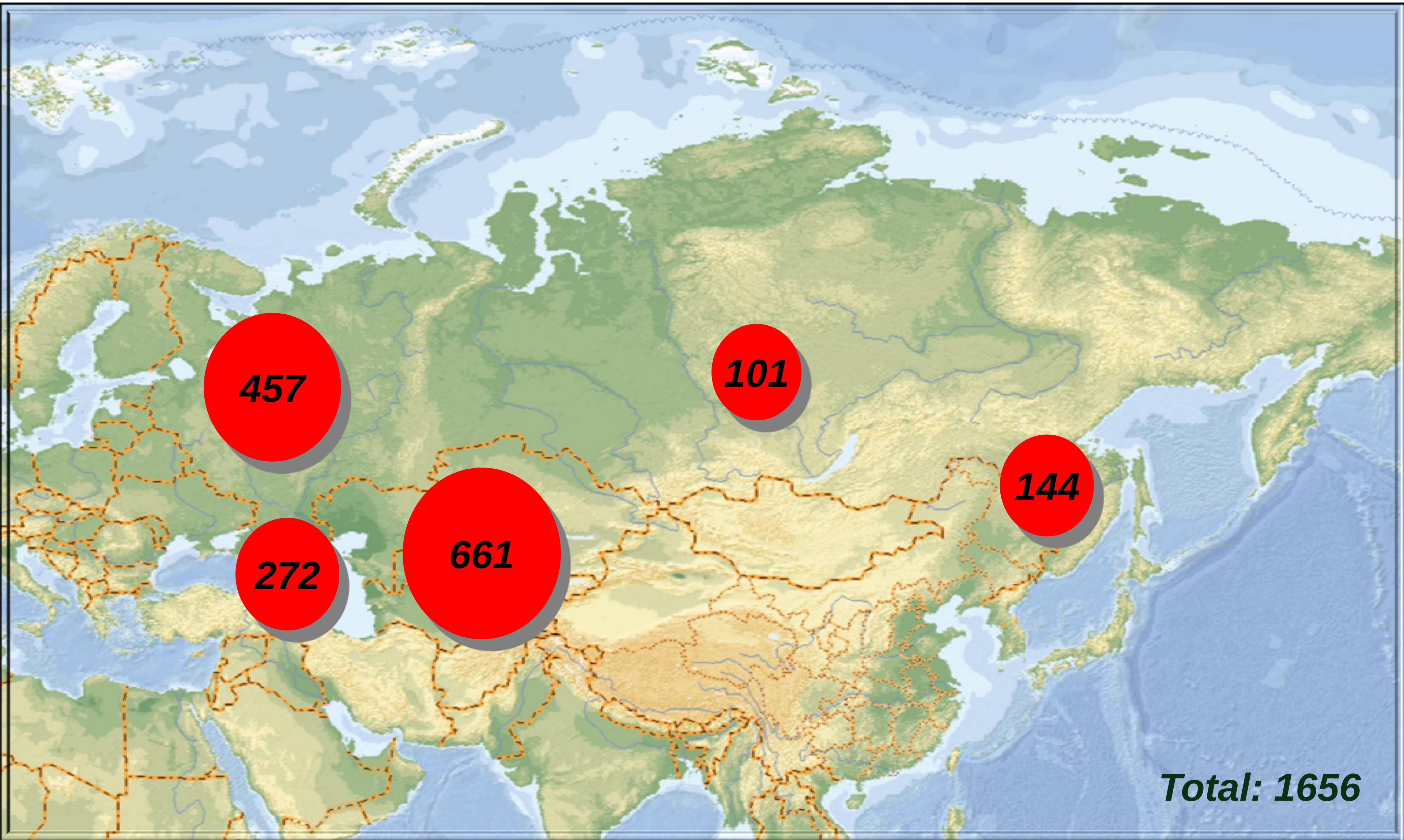
The routes of main collecting missions by N. Vavilov (1916 -1940)



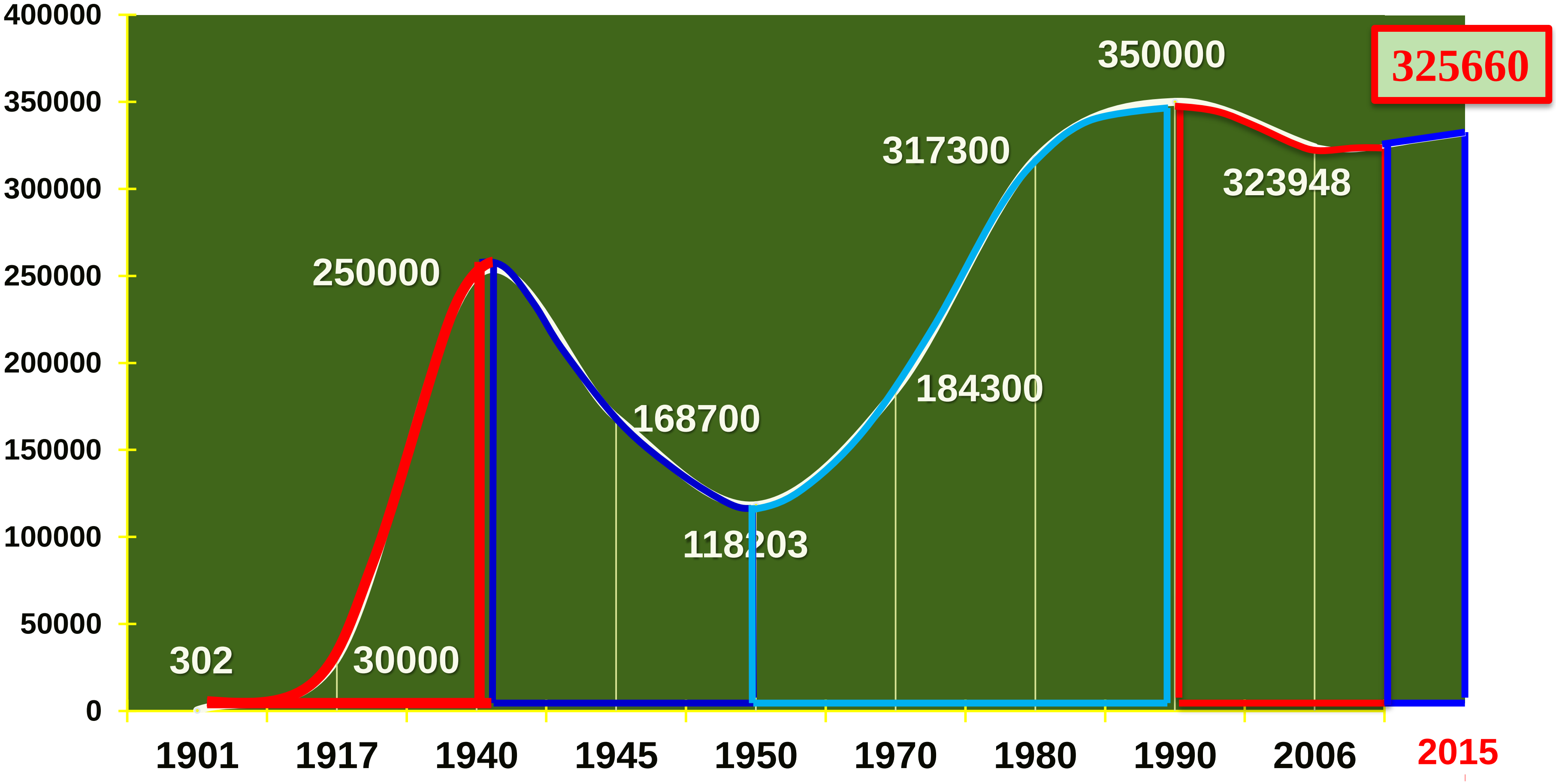
Geography of VIR collecting missions to foreign countries (1908-2015)



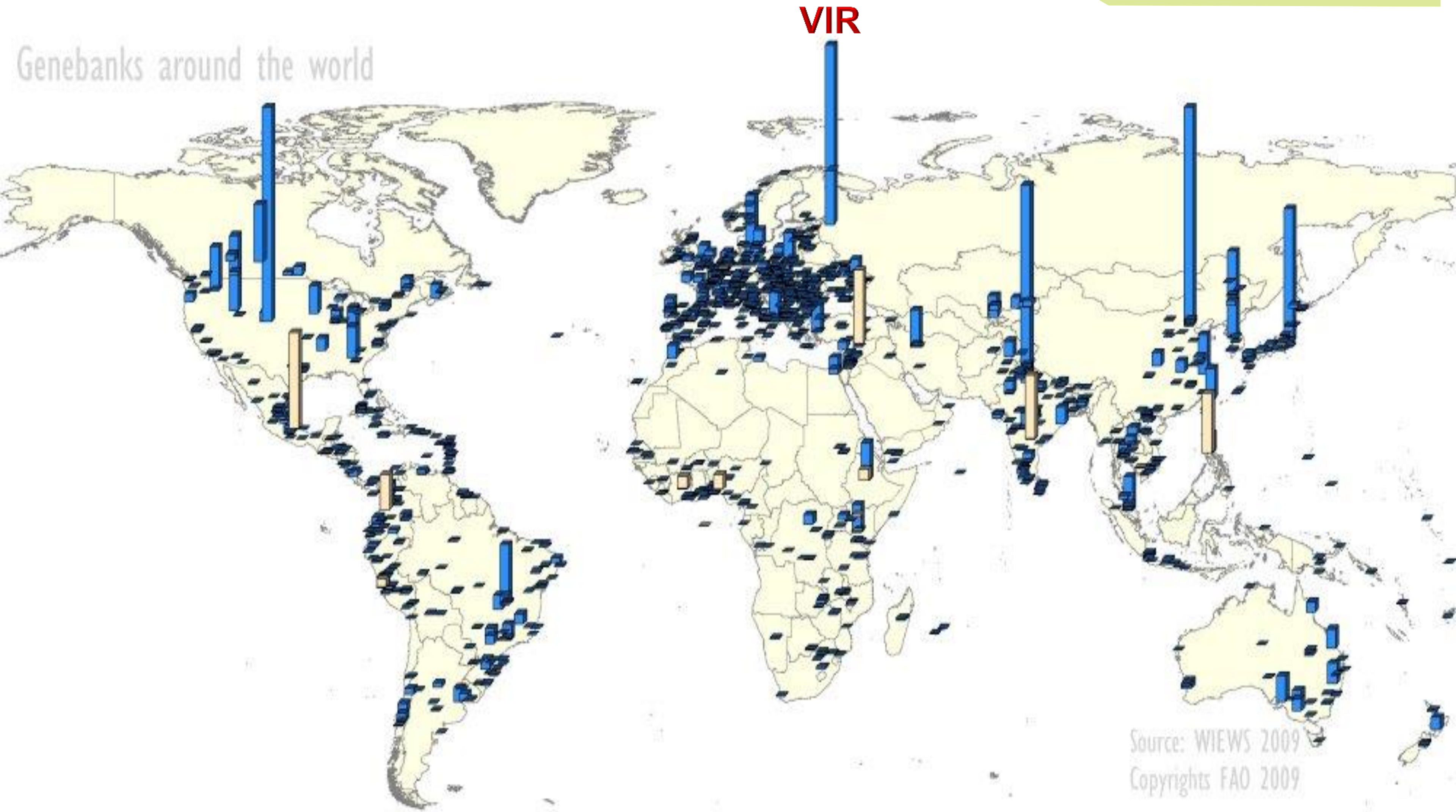
VIR's collecting missions over the territory of the former USSR (1908 – 2015)



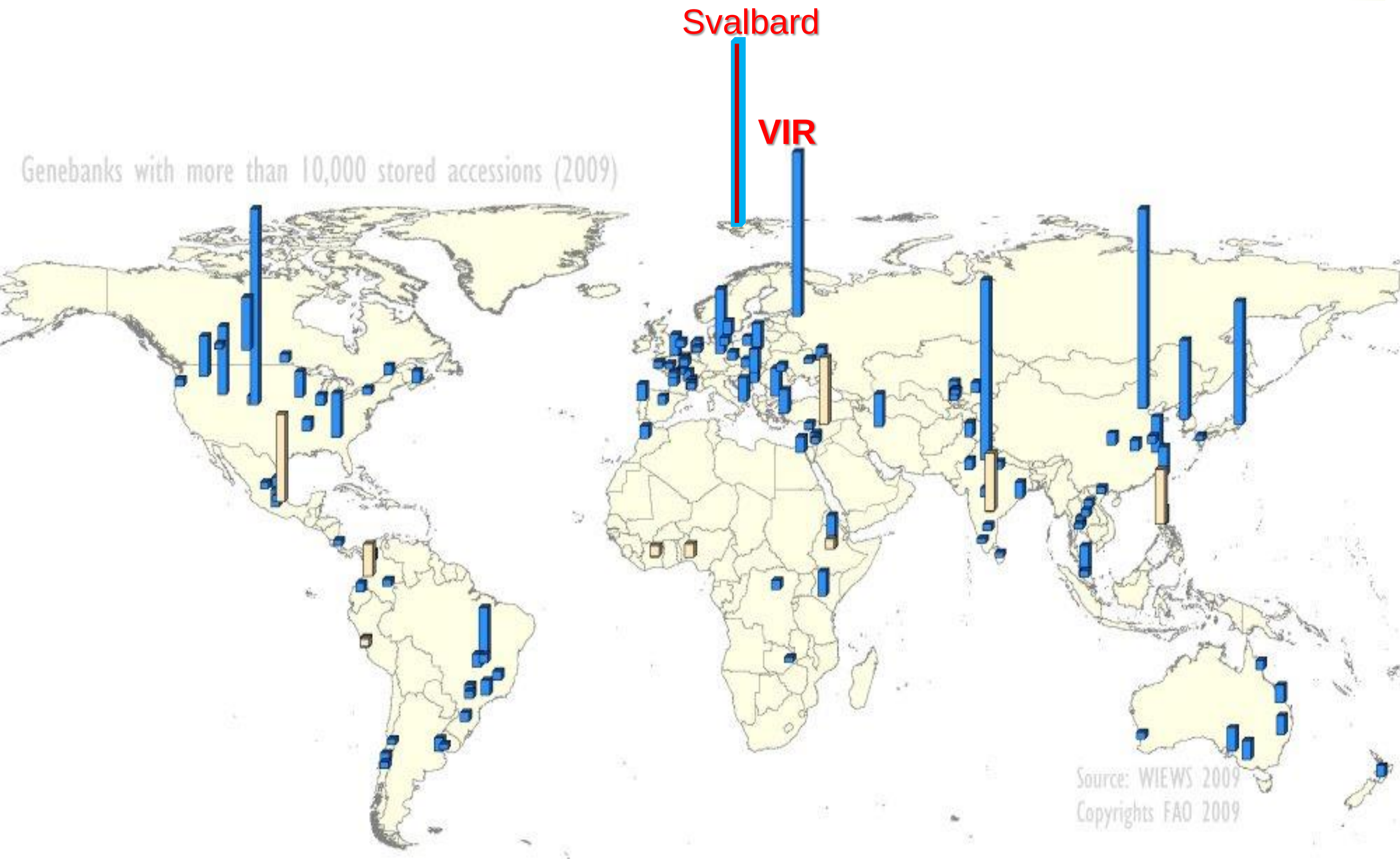
VIR collections dynamics (1901–2015)



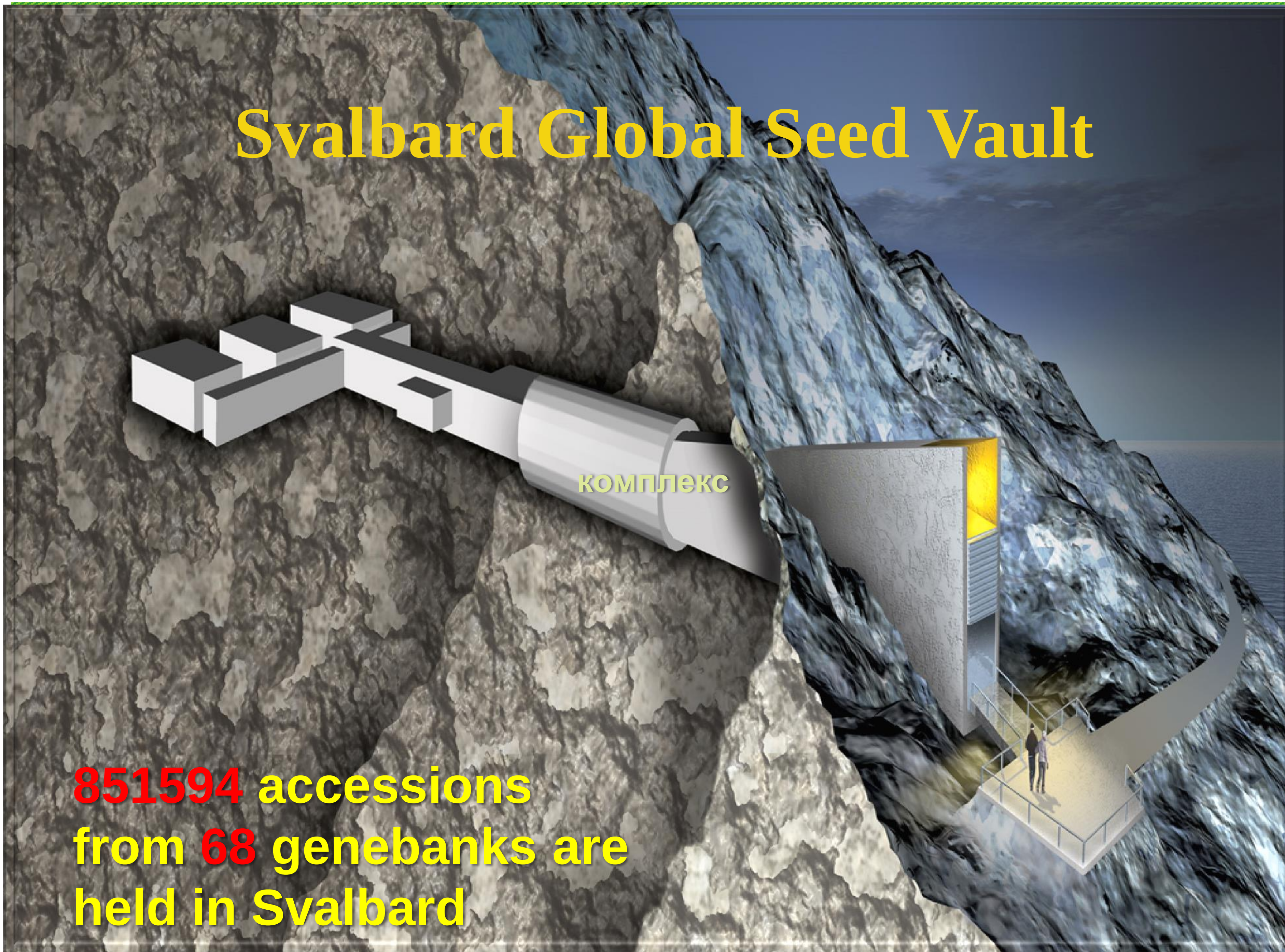
1750 genebanks of the world preserving 7,3 mln accessions (FAO, 2010)



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



Svalbard Global Seed Vault



851594 accessions from 68 genebanks are held in Svalbard

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

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




Genetic diversity of the world's plant resources stored at the Vavilov Institute numbers 325660 accessions representing 64 families, 376 genera and 2169 species.

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

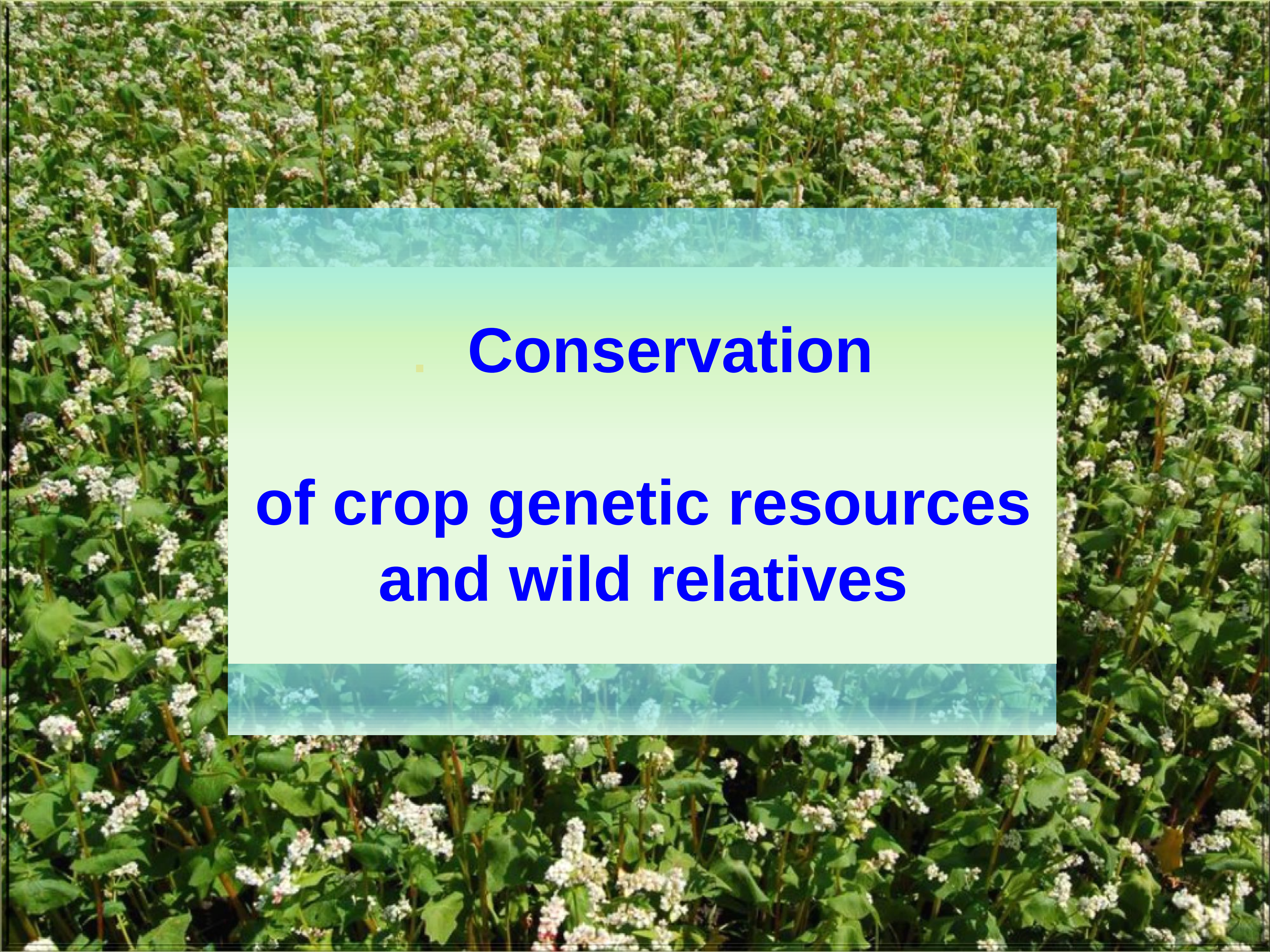
VIR's herbarium collection numbers 324610 specimens.




Dynamics of the numbers in the VIR collections classified by staple crop groups



Crop groups	Number of accessions					
	2010	2011	2012	2013	2014	2015
Wheat, triticale, Aegilops	51662	50568	51234	51580	52409	52658
Rye, oat, barley	36509	36841	36885	36549	36581	36688
Small-grain groat crops	48358	48309	48606	48529	48529	48529
Perennial forage crops	30489	30963	31311	31366	31366	31366
Grain legumes	45845	46141	45438	46317	46135	46344
Oil and fibre crops	27471	27517	27680	27970	27970	28119
Potato	9647	9239	8864	8692	8958	8604
Vegetables	50138	50205	50088	49971	50019	50089
Fruits and berries	23734	23558	23073	22750	22750	22750
TOTAL:	323853	323341	323177	323724	324955	325660


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.)

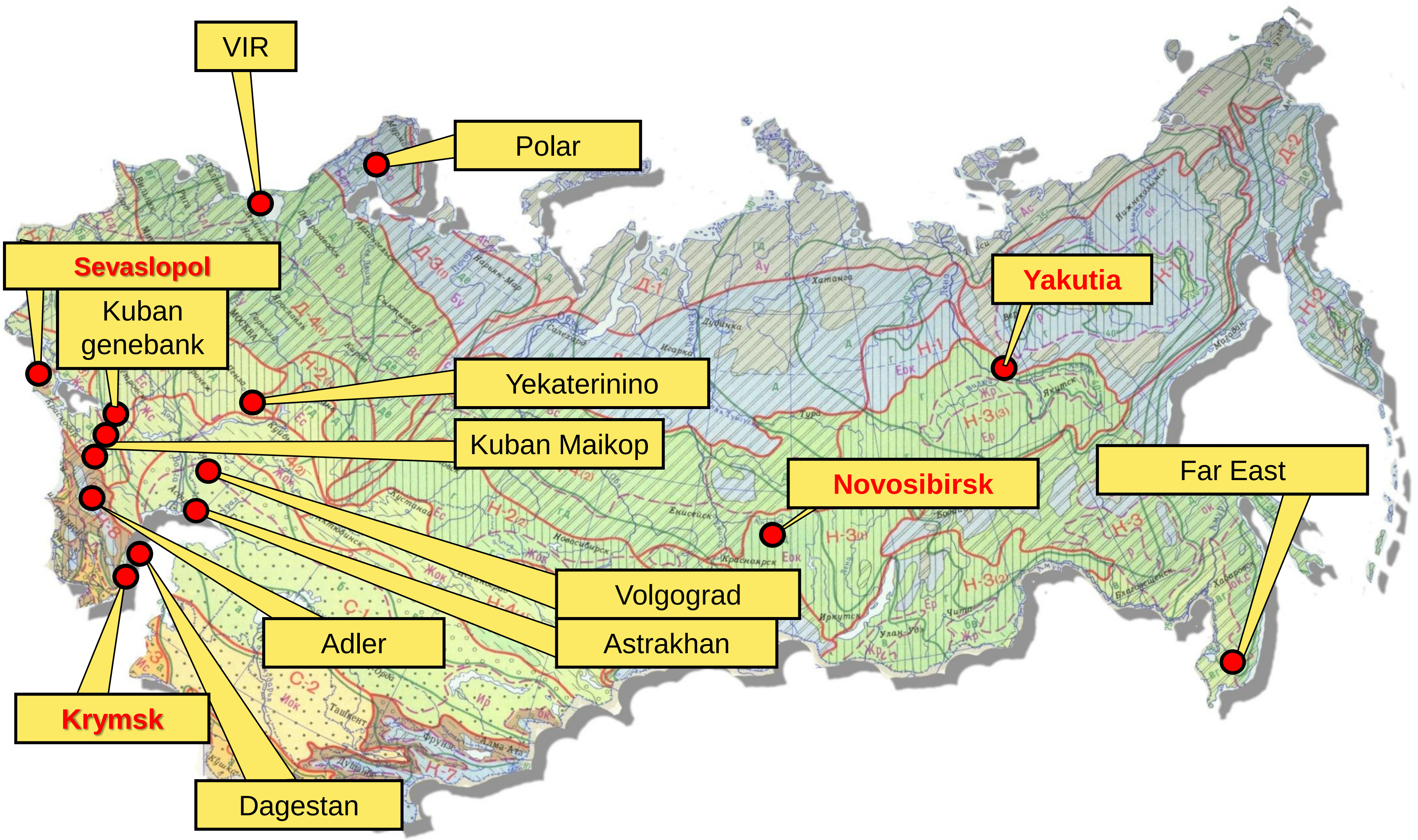
EX SITU

Dynamic

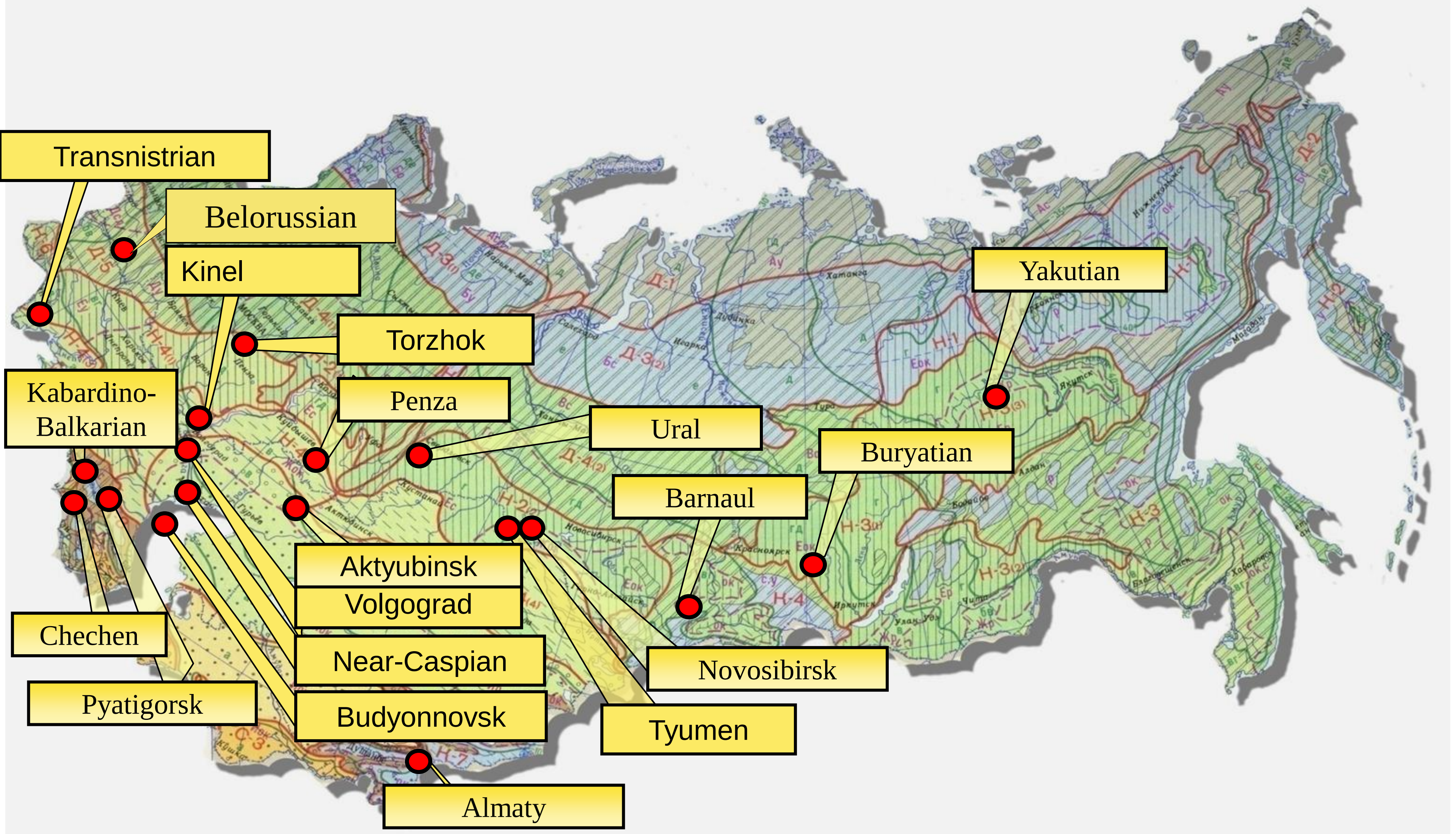
Conservation of individual taxa within their agricultural and natural ecosystems

IN SITU

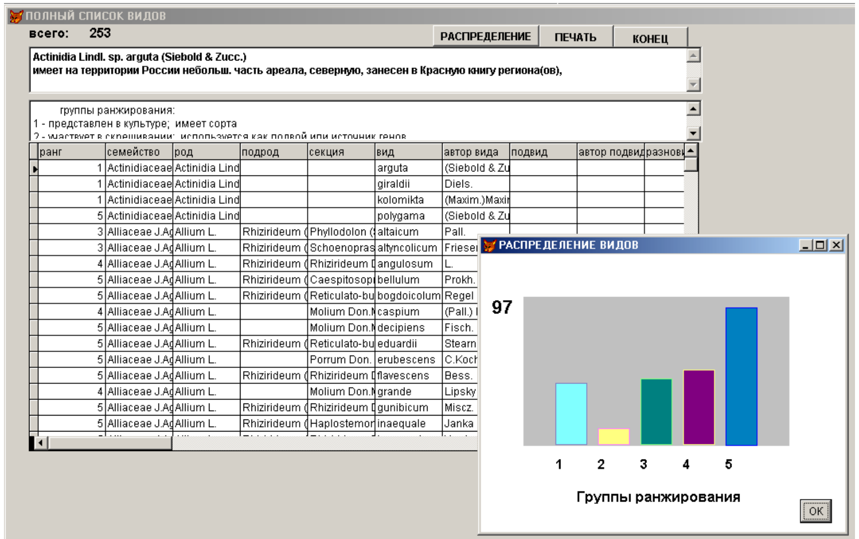
Field genebanks of VIR - branches of the Institute, complying with the global standards of FAO (2015)



Experimental base sites of VIR

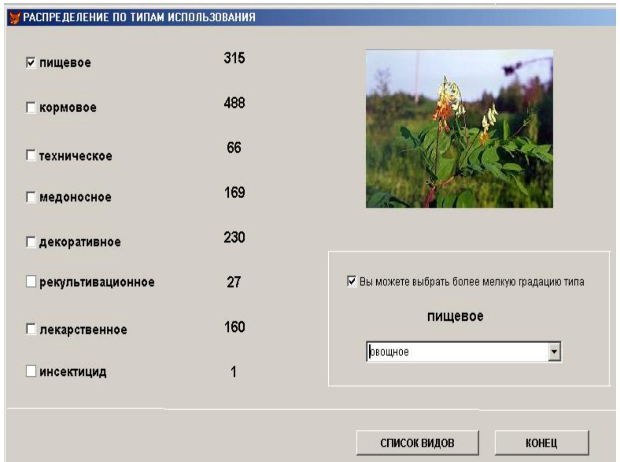


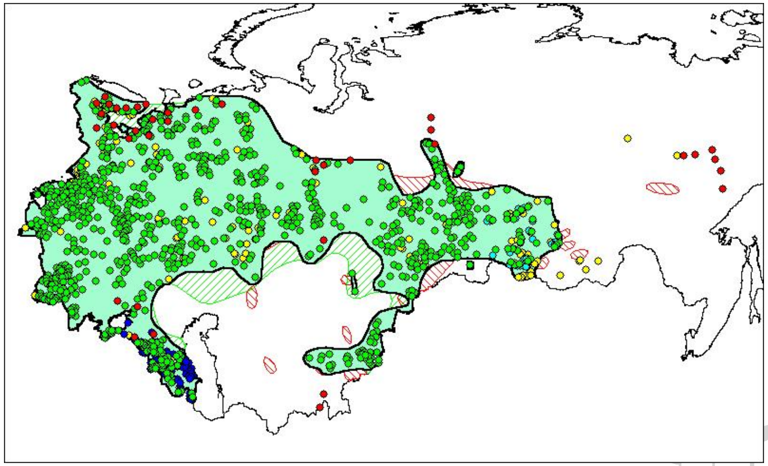
In situ conservation strategy



A database has been developed, containing information on:

a. geographical distribution of plant species (maps of the areas of distribution);
b. taxonomic composition;
c. features of plant growing;
d. trends of utilization.

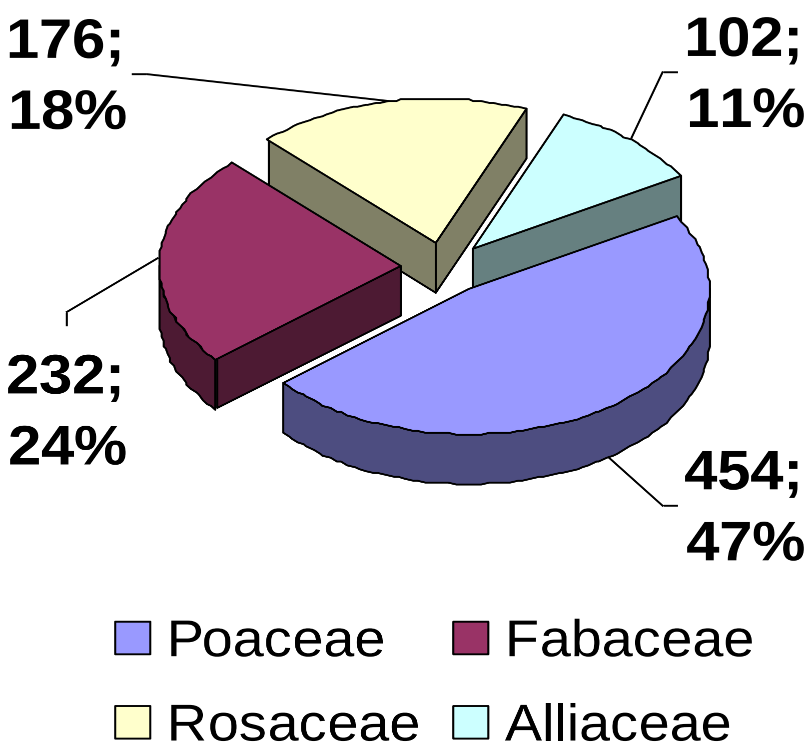




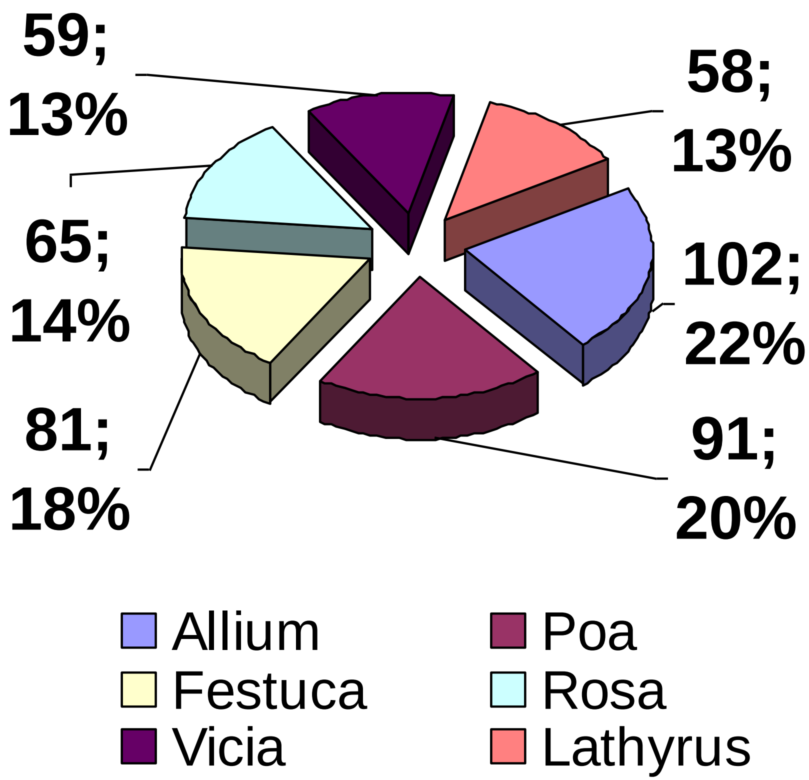
Crop wild relatives (CWR) in Russia

1680 species, 208 genera, 62 families

Species-oriented structure of major CWR families (964)



Species-oriented structure of major CWR genera (456)



Ex 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)



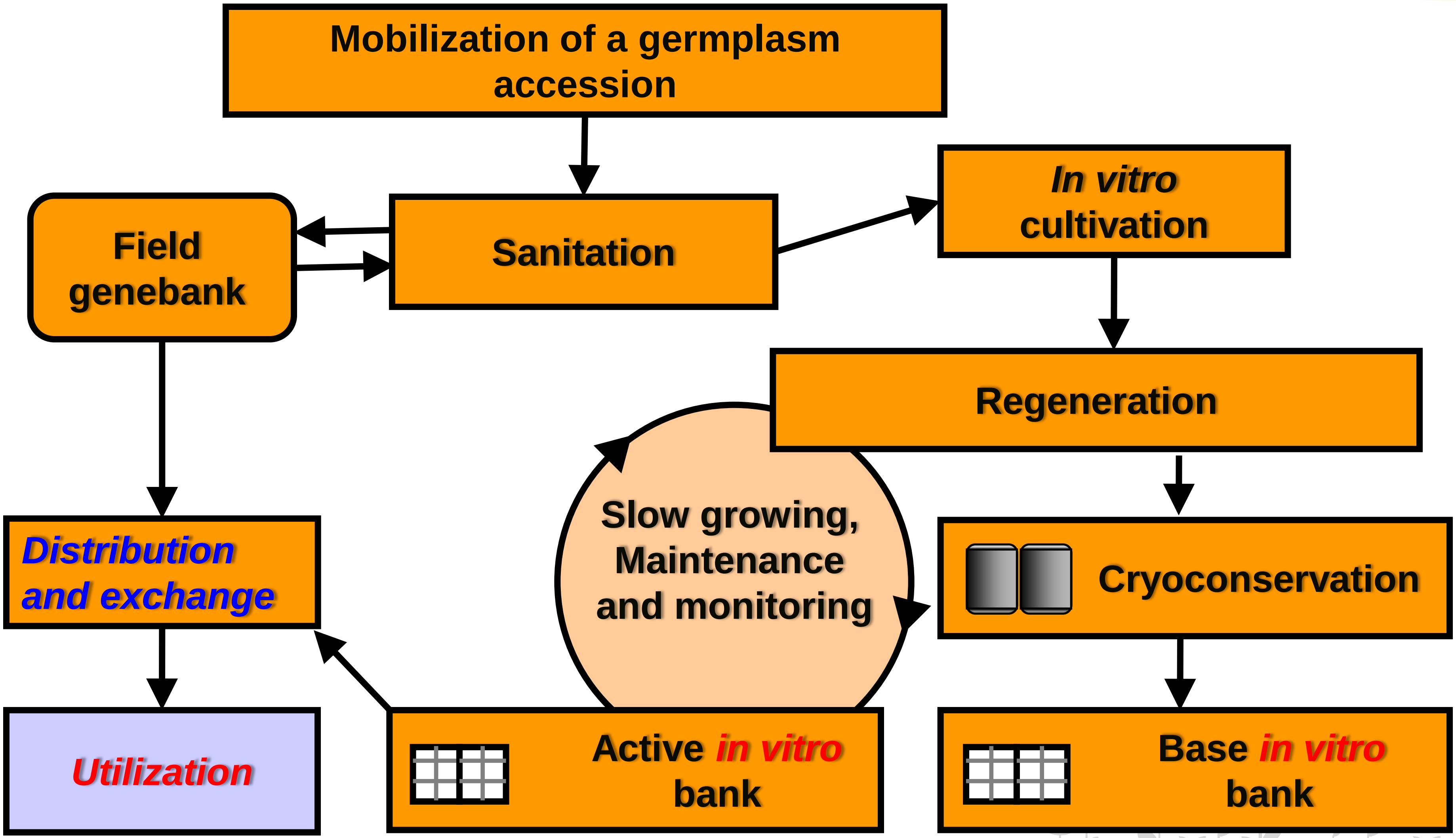
Monitoring of viability of

Guaranteed period of bioresources conservation is more than 100 years

depend upon species traits

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

Conveyor technology of PGR *in vitro* storage



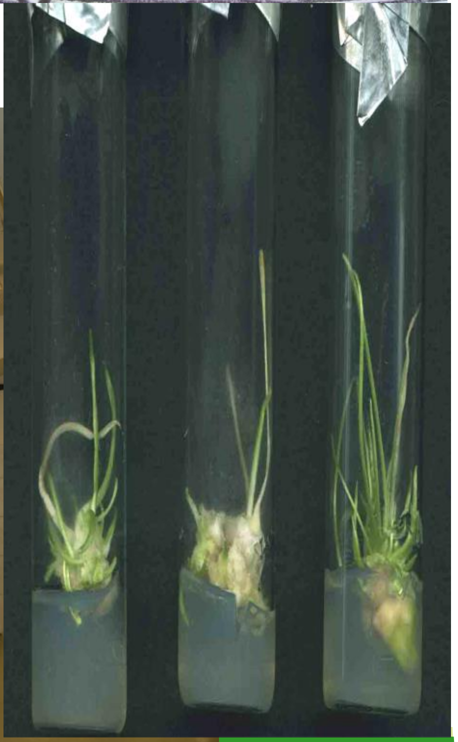
VIR's Genebank contains 572 902 accessions:



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.

II. Sustainable utilization of crop genetic resources and wild relatives

Dynamics of germplasm dissemination from the VIR collections in 2009–2014

No	Crop	2009	2010	2011	2012	2013	2014	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 2006-2014 VIR submitted 149 cultivars to the State Variety Testing Committee;

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

77 authorship certificates and 59 patents have been issued.




Cultivars in the State register of breeding achievements (data valid for 03/02/2015)

VIR CULTIVARS

96 SPECIES

476 VARIETIES

TOTAL CULTIVARS IN RUSSIA

507 SPECIES

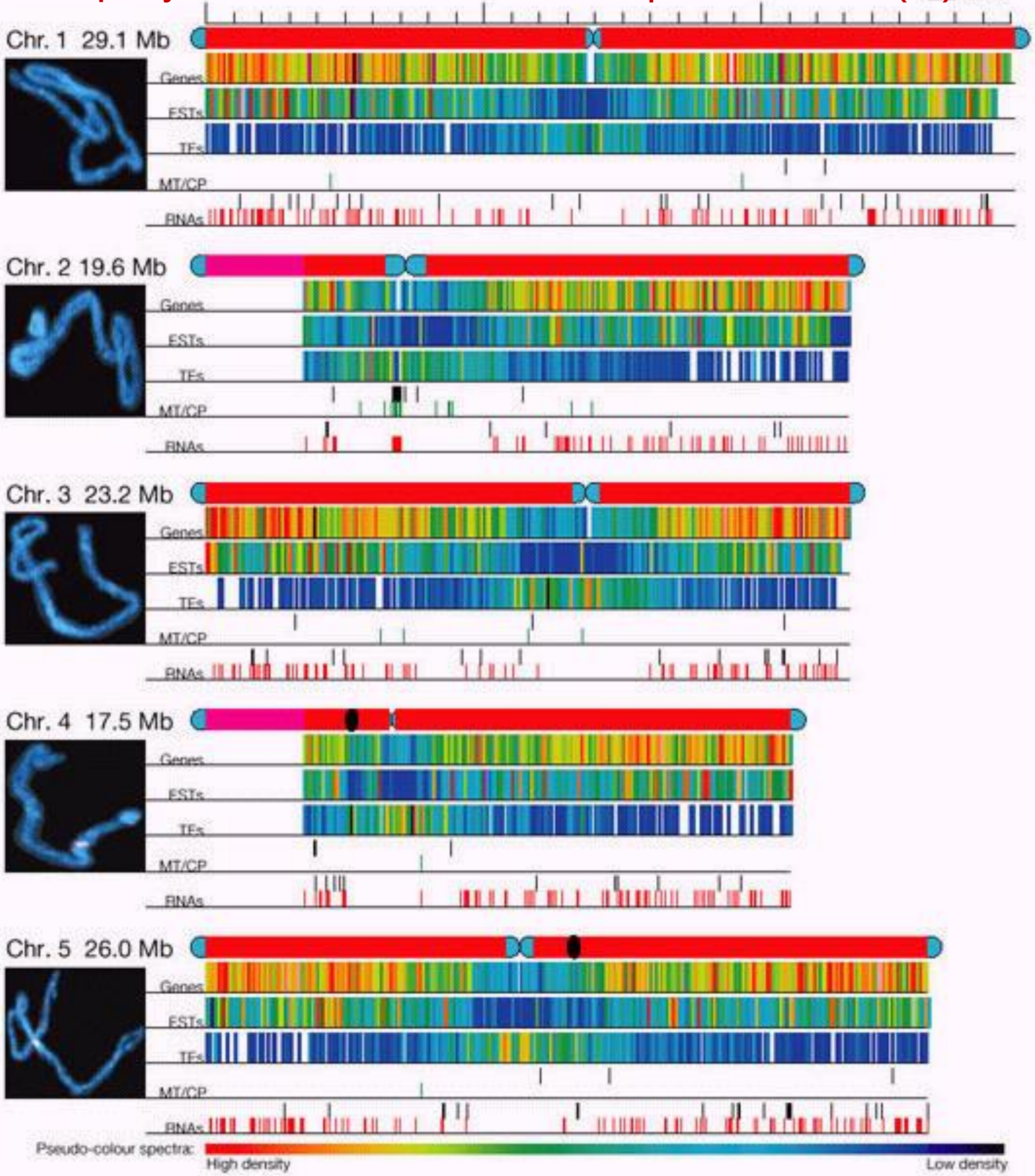
17 862 VARIETIES

(2310 of them of foreign origin)



Genetic resources in the post-genome era: challenges and strategic tasks

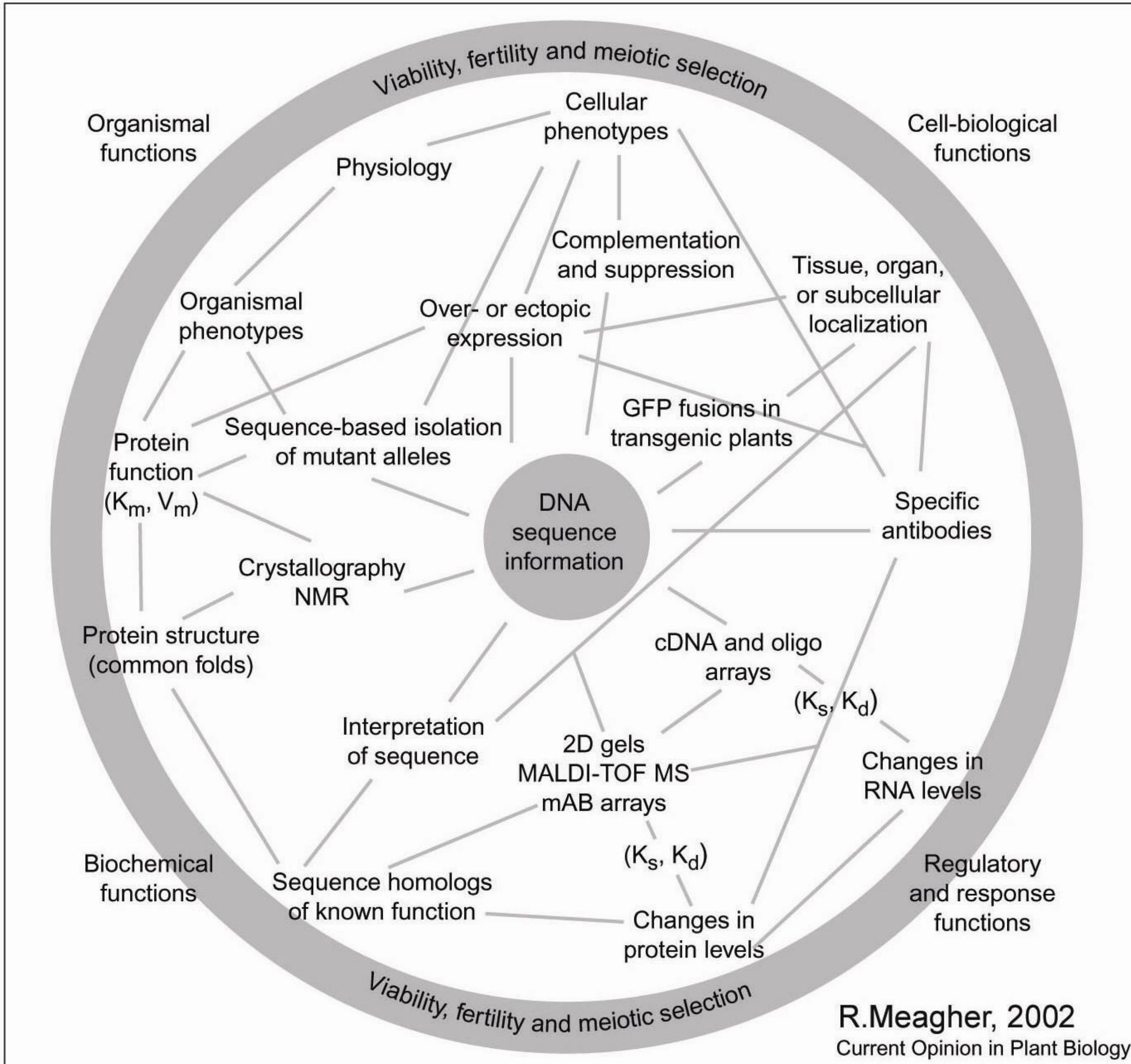
Геном резуховидки Таля – Arabidopsis thaliana (L.)



14 декабря 2000 г.

The genome contains 25,498 genes encoding proteins from 11,000 families.

Post-genomics world of science



Research focus is the information on genome sequence (central circle).

This information serves as a platform for analyzing processes at various levels:
- biochemical;
- genetic;
- regulatory;
- cellular;
- organismal;
- evolutional.

Methods applied for these purposes are shown between circles.

Dominating role in the post-genomic period is being assigned to the researches that start with sequencing of the genome and proteins, and culminate in identification of the functions of individual genes and proteins, alongside with their evolutional origin.

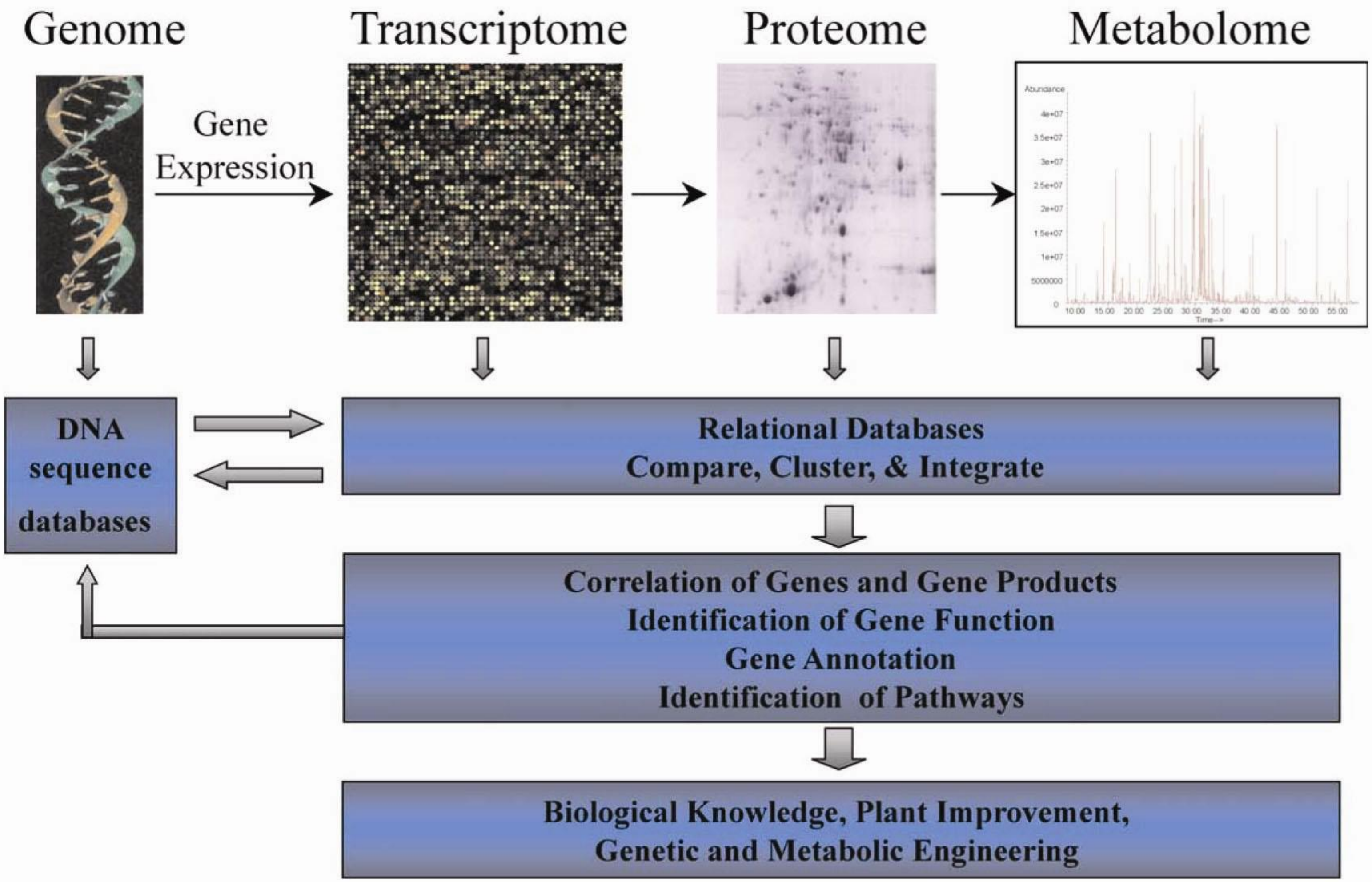
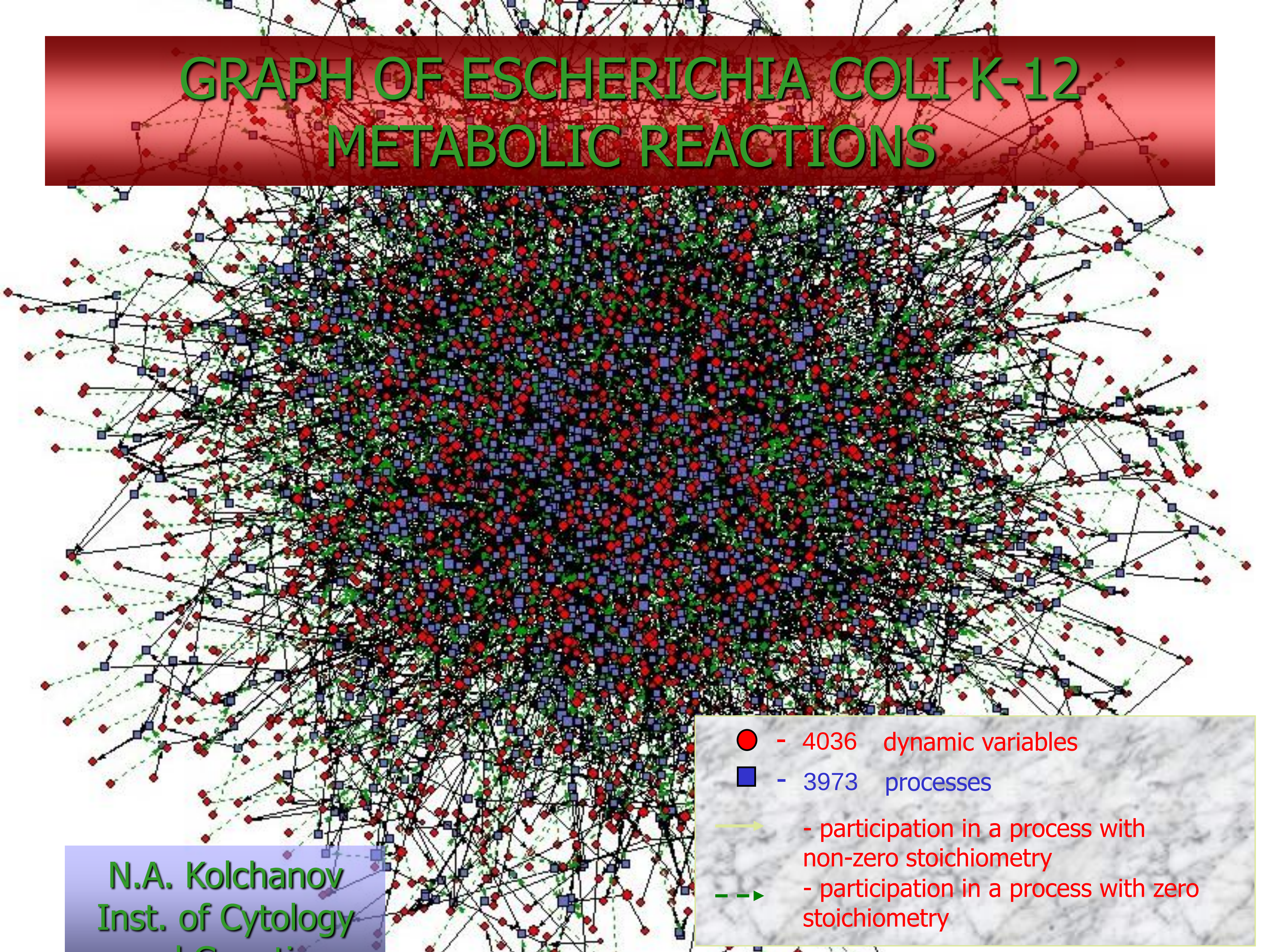


Fig. 1. Integrated functional genomics. The effects of gene perturbations are evaluated at multiple levels including the transcriptome, proteome, and metabolome. Changes in the metabolome occur as a consequence of those changes in the transcriptome that result in changes in the levels or catalytic activities of enzymes. Therefore, metabolome analysis is a valuable tool for inferring gene function.

GRAPH OF ESCHERICHIA COLI K-12 METABOLIC REACTIONS



N.A. Kolchanov
Inst. of Cytology

Solving the problems of:

1. Genetic erosion.
2. Genetic vulnerability.
3. Genetic integrity.



1. Conservation of maximum specific and intraspecific genetic diversity of cultivated plants and their wild relatives worldwide for future generations on the basis of international cooperation and integration.



2. Setting up a global identified genetic stock for breeding various types of cultivars capable to solve the problem of food security under the conditions of possible worldwide and regional climate changes.

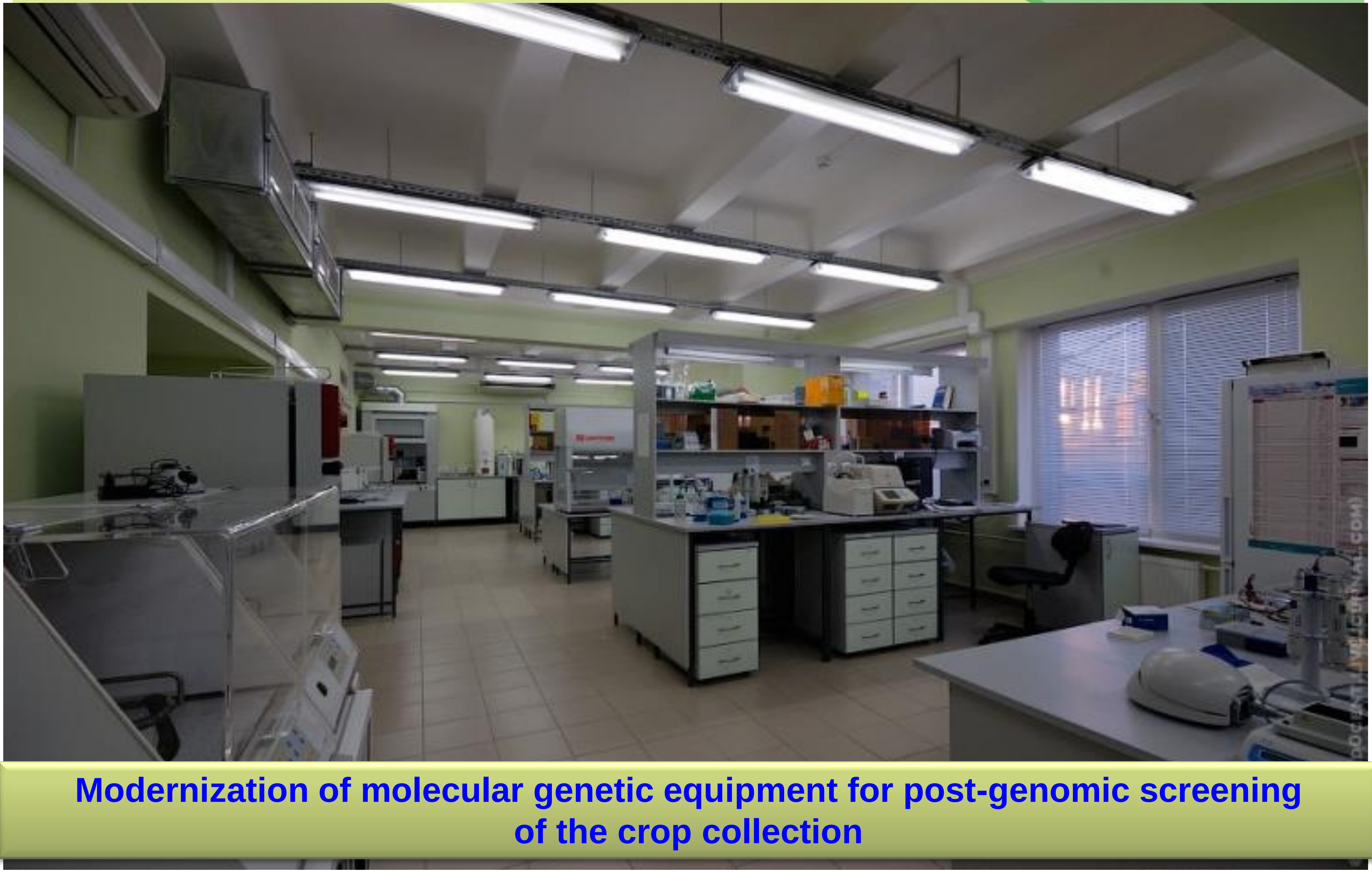
  

"It is better to display excessive concern now, than to destroy all that has been created by nature for thousands and millions of years ..."

N. I. VAVILOV


Thank you for attention!

VIR's centre of collective use



Modernization of molecular genetic equipment for post-genomic screening of the crop collection

A shift of the paradigm in nature resource management

The changing worldview strategy of the mankind declares the need for the world community to shift from unrationalized consumerism to the path of ***sustainable development.***

Sustainable development – **is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs (*Agenda 21, Rio-de-Janeiro, 1992*).**

Ecologization of production:
the opinion of FAO



"…large-scale conversion of global agriculture to organic practices could not only eradicate world hunger and contribute to the health of human population but also improve the state of natural environments".

Organic Agriculture and Food Security,
FAO Report, 6 May 2007

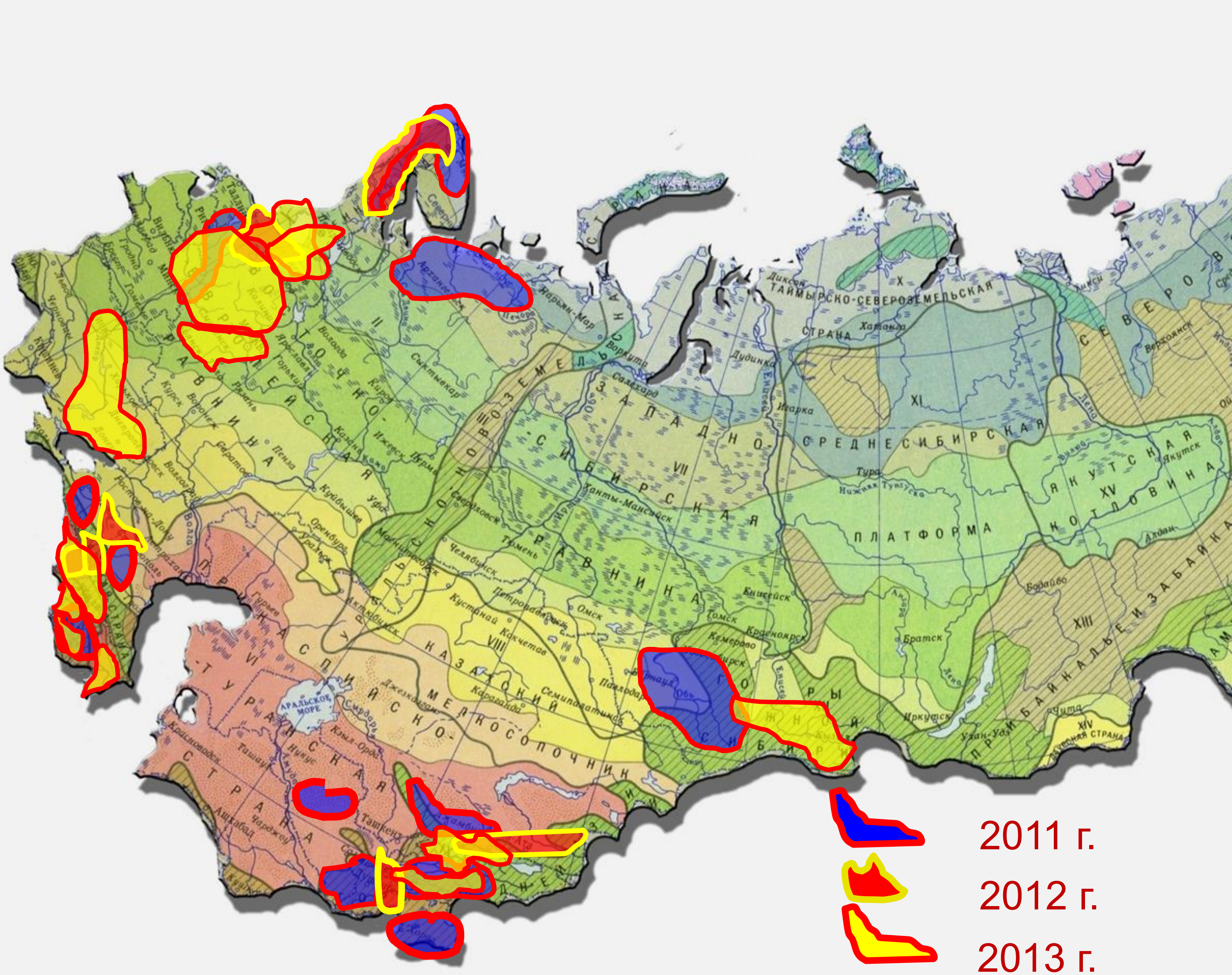
Ecologization of production:
strategic trend



In view of this, a majority of the world's developed countries regard ecologization of agricultural and food production as a strategic trend to ensure food security.

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





36 missions
in 2011-2013

A way to genetic impoverishment? (1)



Disappearing biological diversity as a global problem of intensive agriculture

Agriculture is developing in all the world displaying the following trends:

- **towards high productivity** – thanks to the use of the latest models of modern equipment and machinery, plant protection techniques, and vast areas under monoculture;
- **towards capital intensity** – hired workers instead of farmers;
- **towards energy intensity** – strongly depends on fossil energy sources and irrigation.
- **towards using a lesser number of highly productive breeds and varieties, partially genetically modified.**

A way to genetic impoverishment? (2)



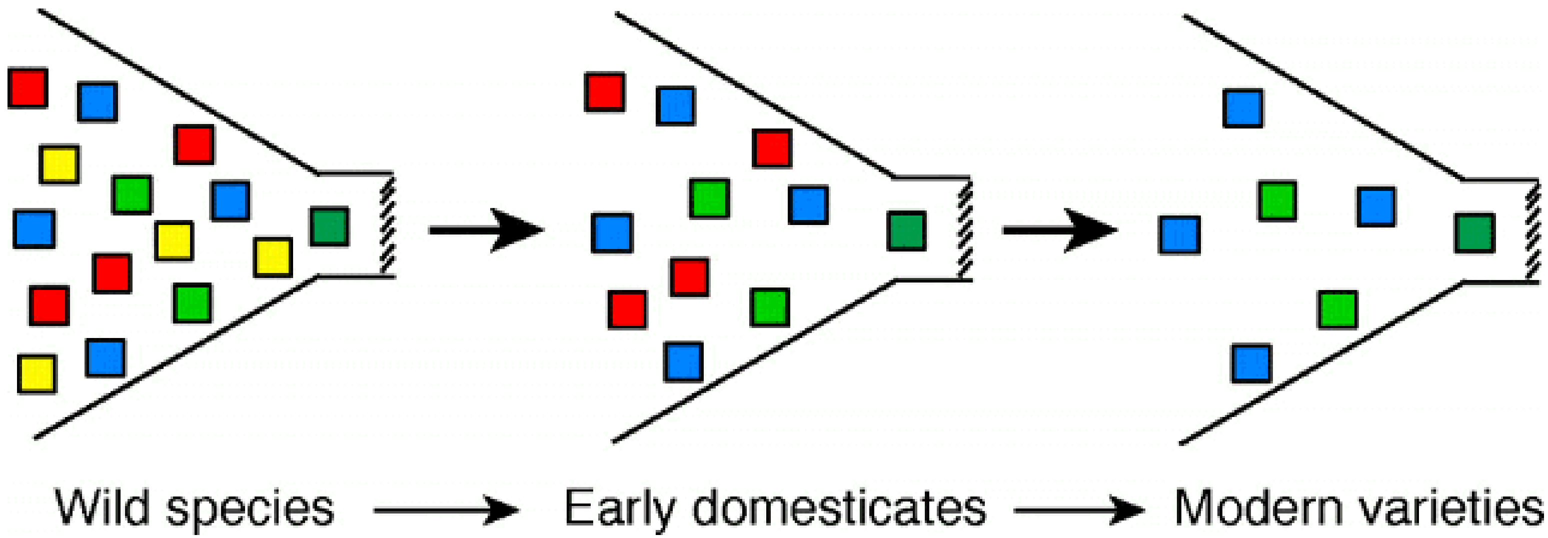
- **15 species** of cultivated plants supply **90%** of the energy required by the world’s population to maintain life;
- **rice and wheat** supply **50%** of such energy.

- **Decrease in the diversity of crop varieties**: wheat - **90%**
  rice - **70%**
  maize - **60%**
  crops on the whole - **75%.**

- Serious problems with plant diseases (quick dispersal) in combination with the development of resistance to pesticides.
- Vulnerability of agricultural crops due to their uniformity.

Loss of genetic diversity during crop domestication

(Tanksley, McCouch, 1997)



Just as the diversity of species we depend on is a small fraction of the species available to us, so is the genetic diversity with those species a small fraction of the genetic diversity actually present in them. The species we depend on have become more and more genetically uniform.

While making plans for collecting new genetic material, it is necessary to take into account:

- northing and desertification processes in Russia’s plant production industry;
- optimization and rational deployment of staple crops;
- modernization of the structure and deployment of plant breeding and seed production centres throughout Russia;
- global tendencies in the development of third-generation food technologies;
- genetic resources as new sources for bio- and chemical technologies (alternative fuels, etc.);
- prospects and aftereffects of global climate changes.

Plant genetic resources



GENETIC RESOURCES

Global changes:

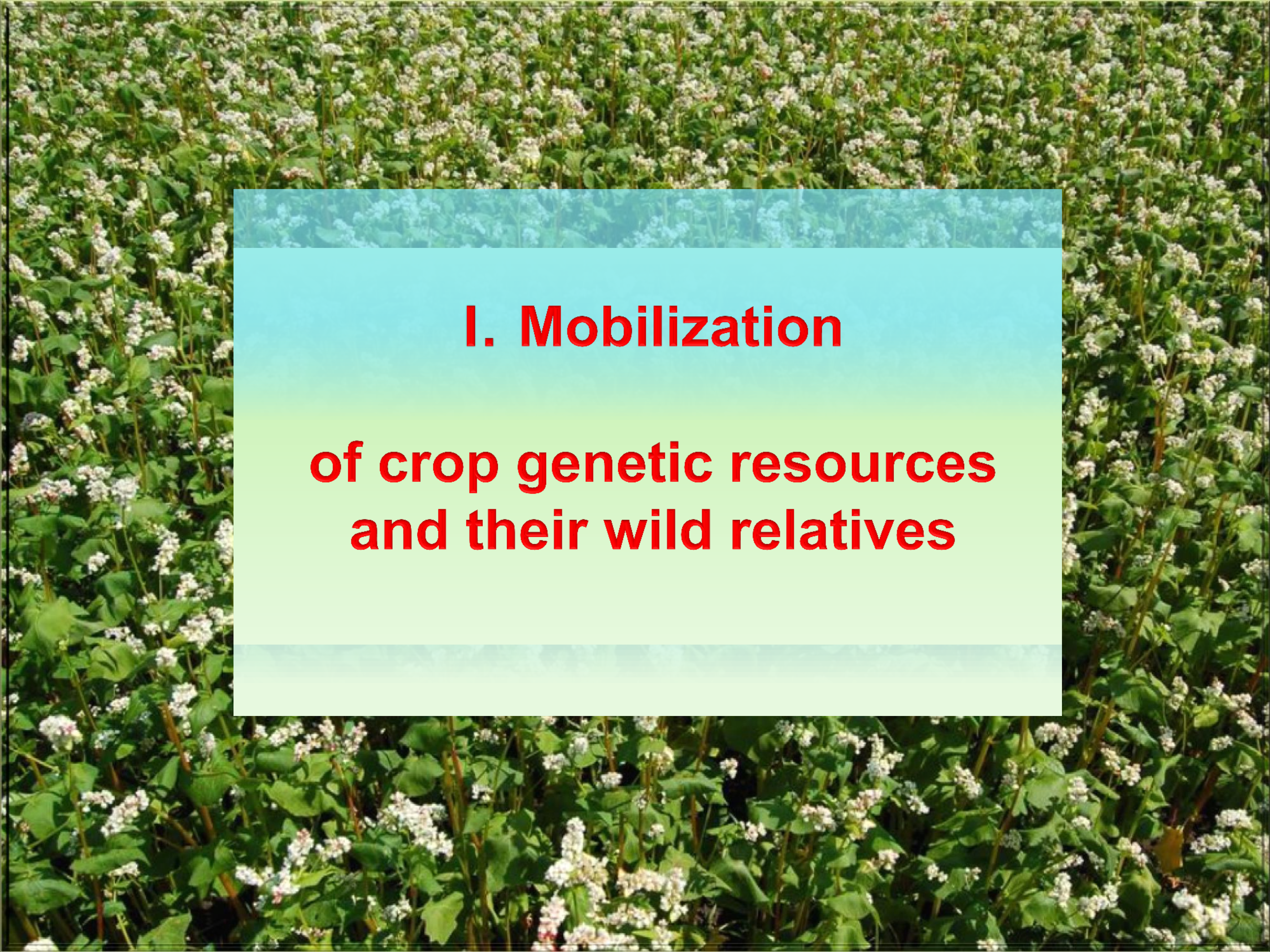
- Economy
- Demography
- Science/Technology
- Climate
- Biopolitics
- Privatization

Bioindustrial products:

- Bioenergy
- Pharmaceuticals
- Cosmetics
- GM crops

Sustainable development of the society:

- Food products
- Human health
- Social stability
- Agro-ecosystems
- Natural environment
- Local economic systems


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:



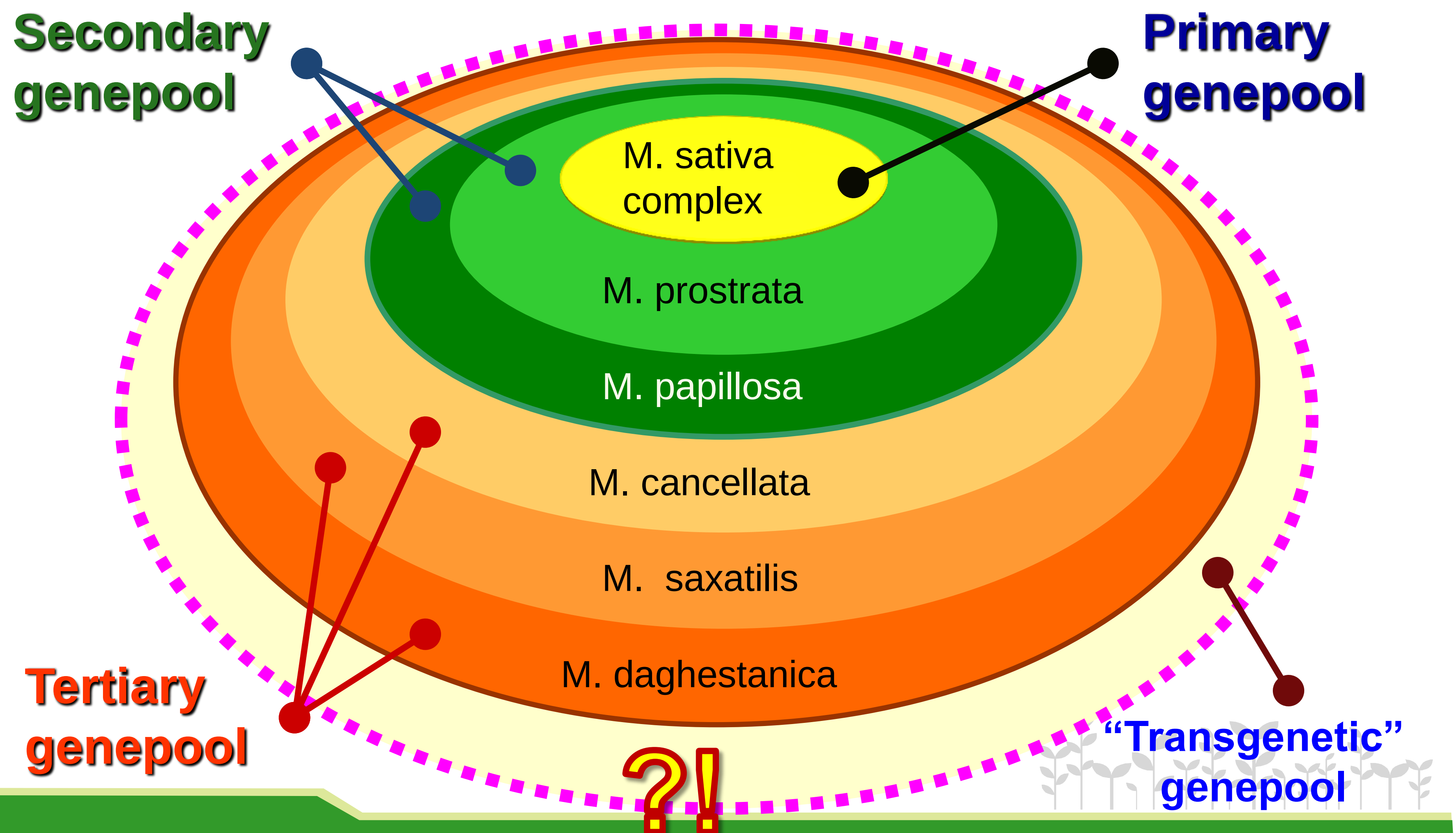
- analysis and evaluation of the global plant genetic diversity in nature and in genebanks;
- systematic inventorying (revision) and evaluation of genetic diversity held in the genebank;
- identification of “gaps” in the collections held in the genebank;
- systematic analysis of national breeding programs,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

The concept of crop genepools

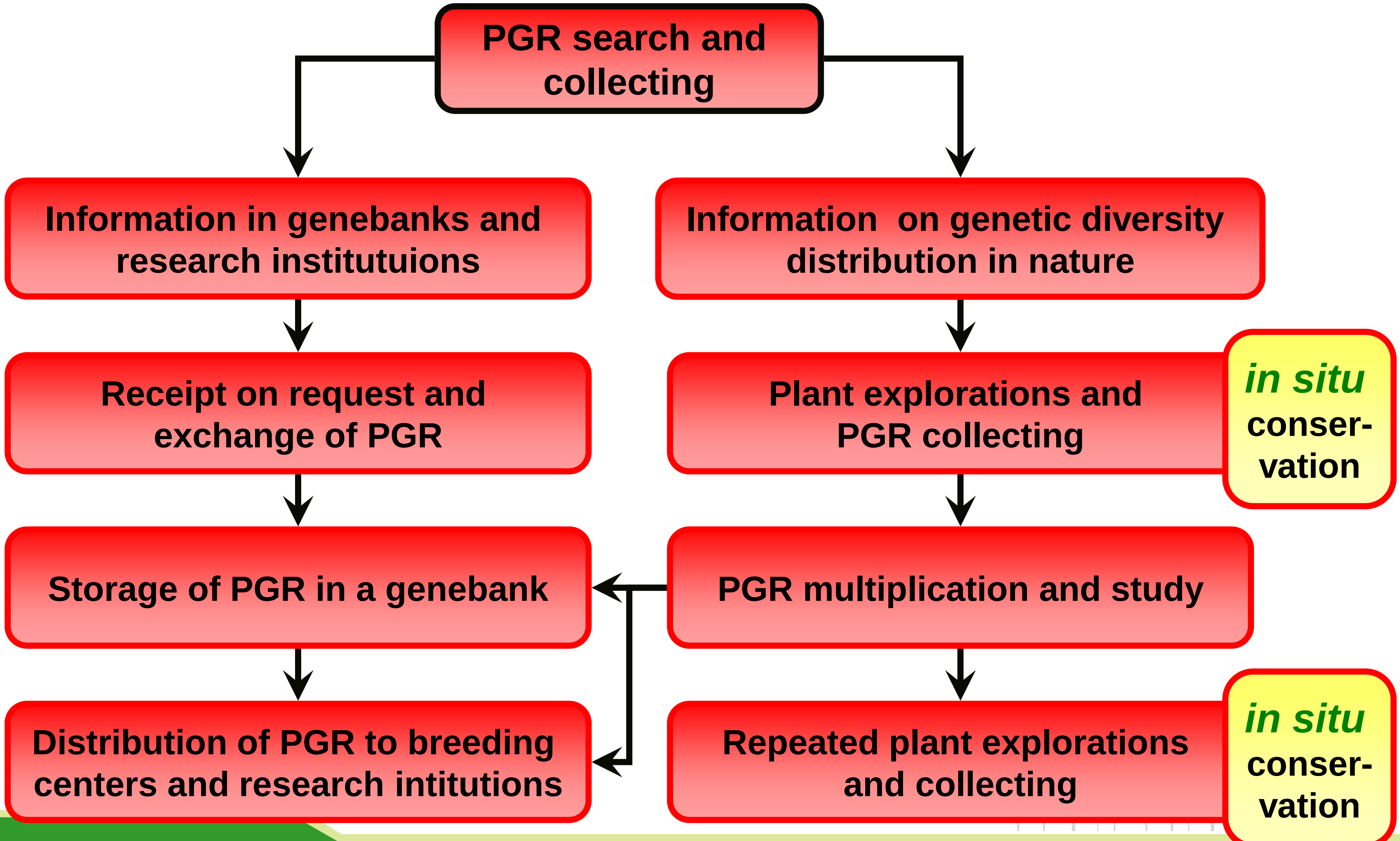
Harlan и de Wet (1971) offered a genepool-based hierarchy of categories for cultivated species. On the species' level and higher, they identified three genepool categories:

- Primary genepool (GP-1) consists of a cultivated species and those wild relatives that are easily crossed with it and freely exchange their genes.
- Secondary genepool (GP-2) is a group of wild relatives which are able to cross with the cultivated species, but there are barriers hindering the exchange of genes.
- Tertiary genepool (GP-3) includes such species that can make crosses with the cultivated one only with the help of biotechnological tools. The exchange of genes becomes possible only through artificial transfer.
- "Transgenetic" genepool (GP-4) comprises the super-generis (super-tribal) variability of plants and variability of non-vegetative origin (V.G. Konarev, 1986, *et al*.)

Genepools of *Medicago* ssp.



Methods of PGR search and collecting



The route of the international expedition collecting wild relatives of forage crops over the northwest of Russia (July-August 2013)