PRO-GRACE
PROMOTING A PLANT GENETIC RESOURCE COMMUNITY FOR EUROPE

Funded by the European Union

Why a European Research Infrastructure on Plant Genetic Resources?

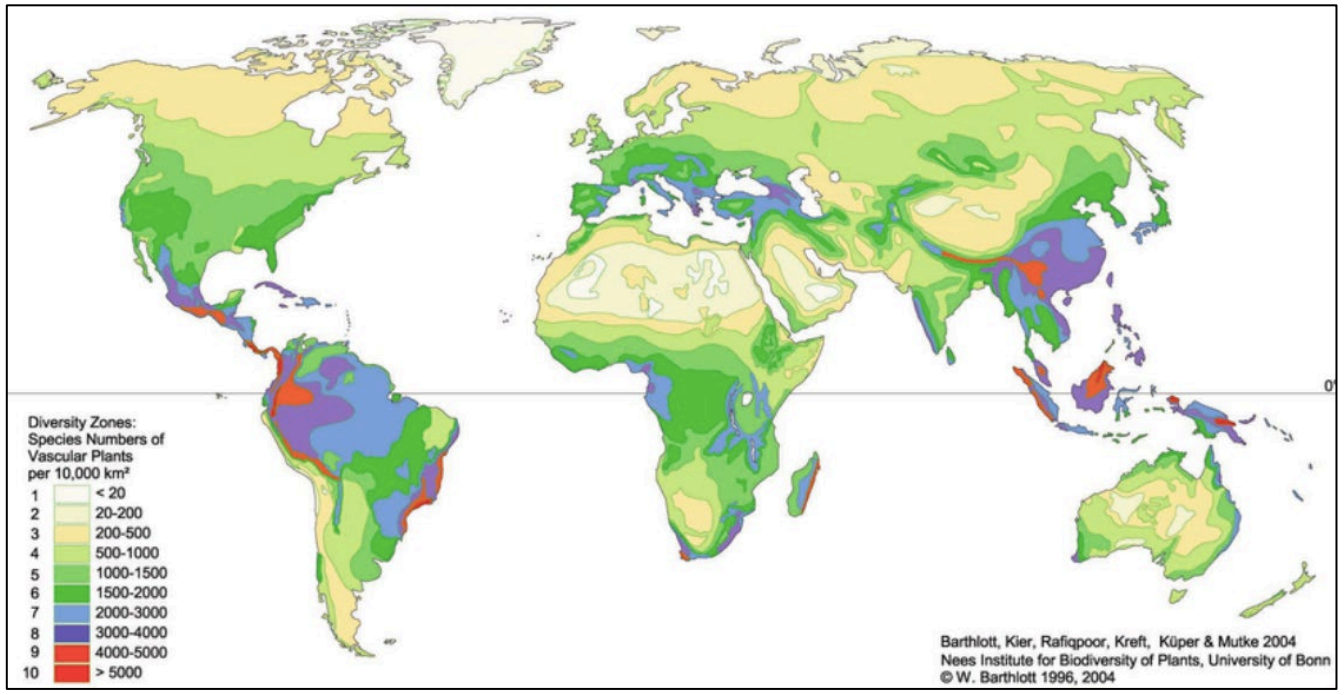
Giovanni Giuliano – PRO-GRACE Coordinator

PRO-GRACE-EMPHASIS Policy Symposium and Workshop

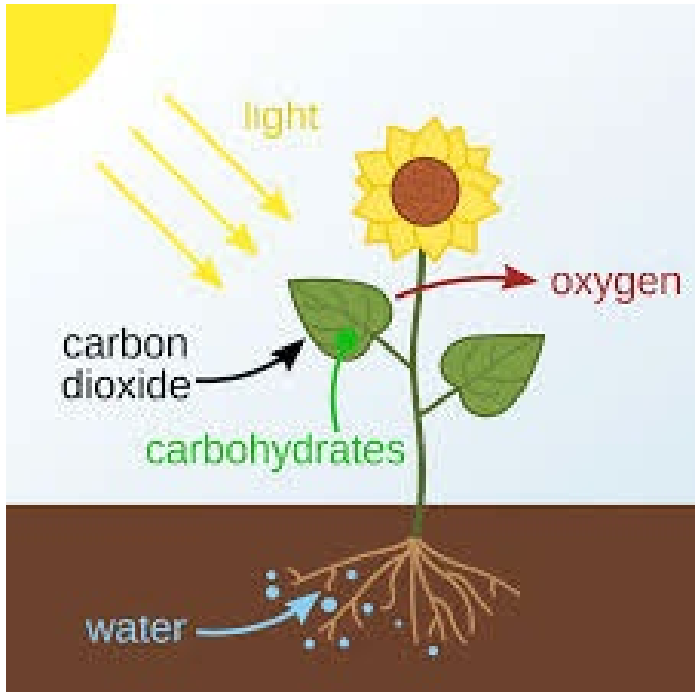
Brussels, 27 June 2024

Plants are essential for life on earth

- About 400,000 known species of terrestrial plants populate Earth. **We use about 40,000 of them as food, medicines, or raw materials for industry (timber, textile fibres, ….)**.
- Plants, through photosynthesis, **fix CO_2** from the atmosphere and produce the **O_2 we breathe** and all the **organic matter** that we ultimately **use as food**.

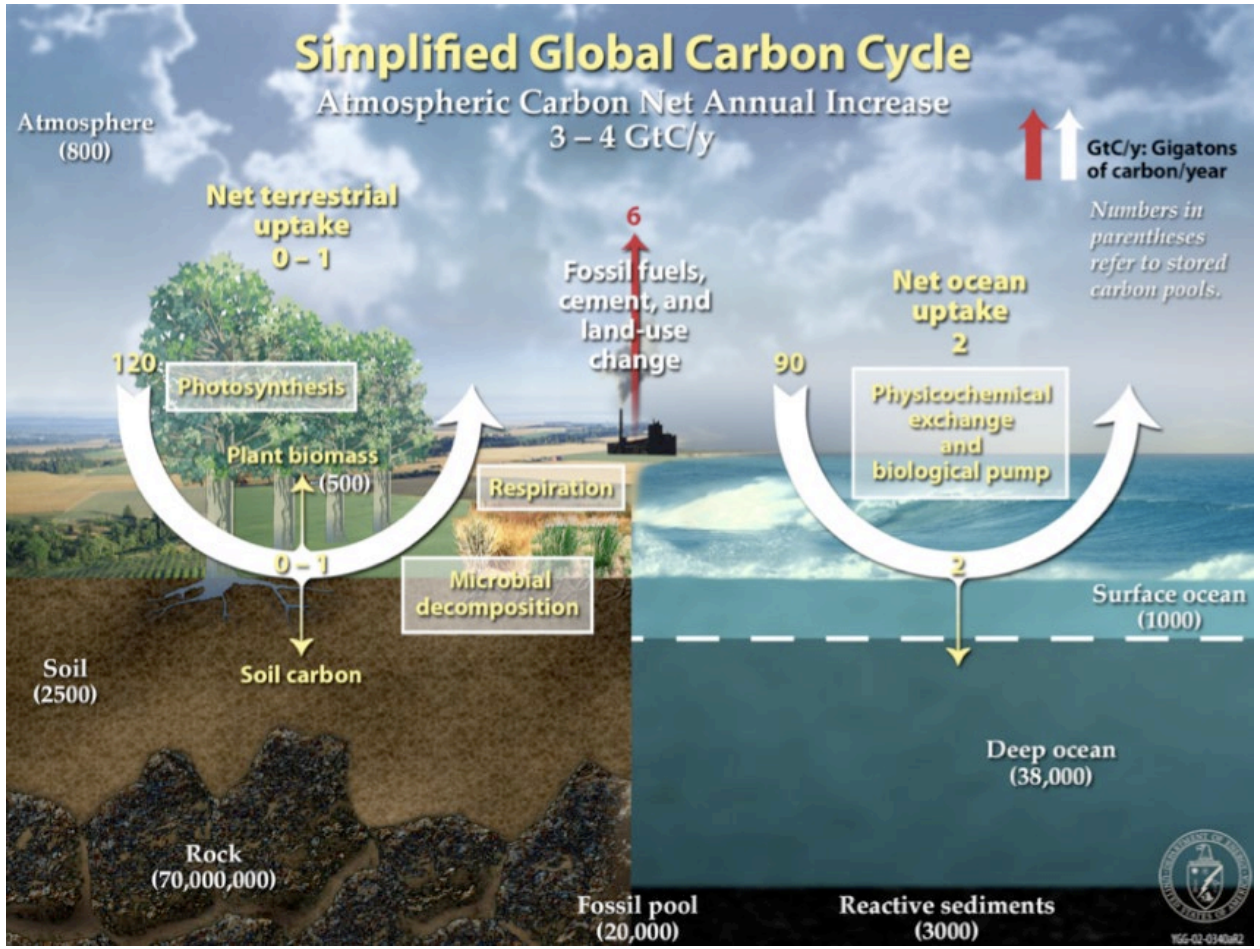


Worldwide distribution of plant biodiversity (Barthlott et al, 1996)

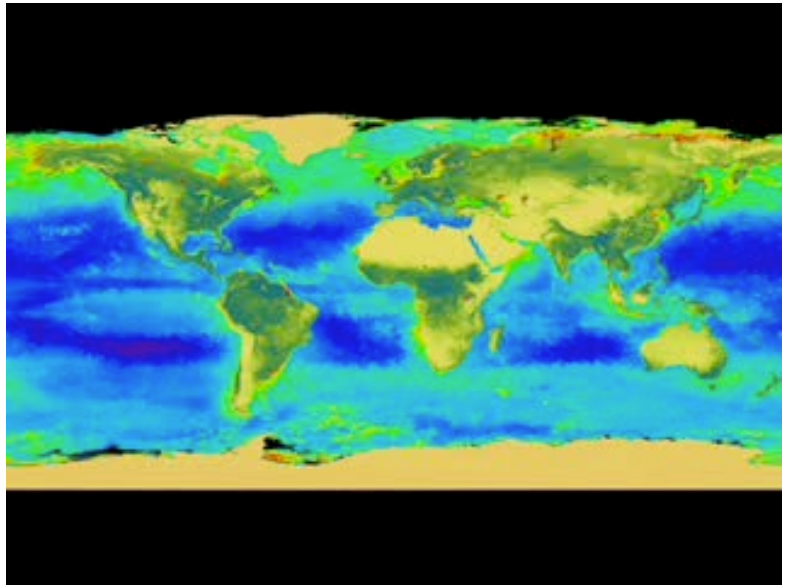


The photosynthetic cycle

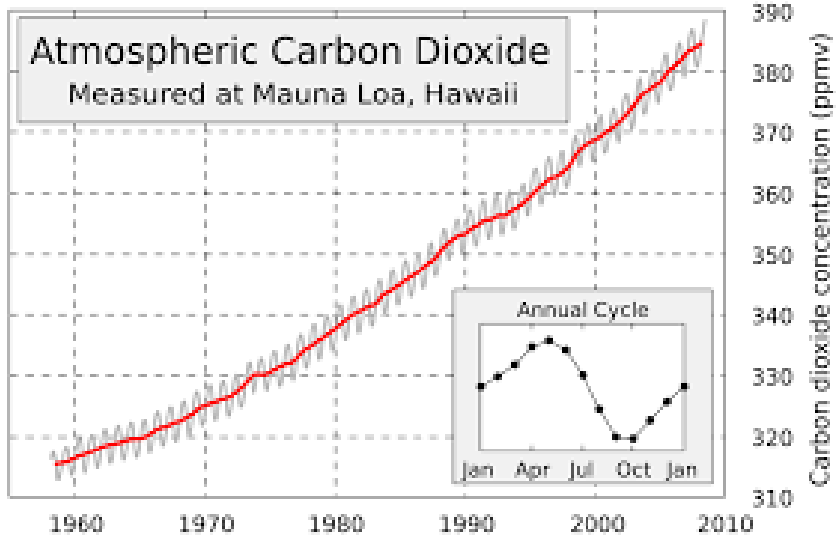
Terrestrial plants are essential for CO_2 capture



The atmospheric carbon cycle



Annual oscillations in terrestrial vegetation

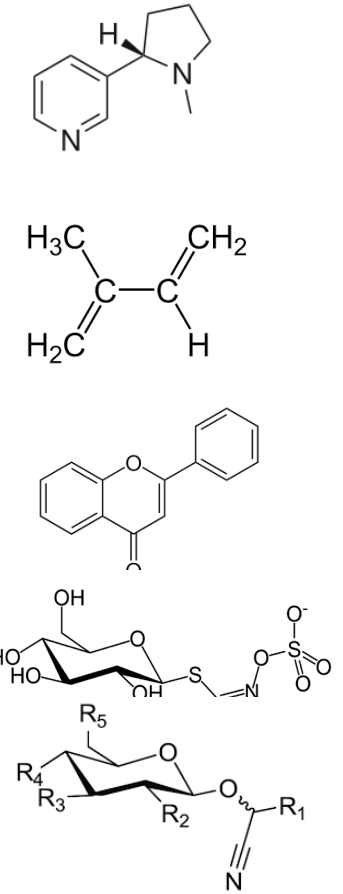


Annual oscillations in atmospheric CO2 concentration

Plants are the planet's best organic chemists

Metabolite class	Examples and applications
Alkaloids	Morphine (analgesic), atropine (used in ophthalmology and as antidote to nerve agent poisoning) , caffeine (stimulant), quinine (antimalarial), vincristine (anticancer agent), capsaicin, piperine (food flavors)
Isoprenoids, steroids and saponins	β-carotene, crocin, (food antioxidants) azadirachthin (insecticide), menthol (aroma), artemisinin (antimalarial), steviosides (sweeteners), cannabinoids (treatment of chronic pain), vitamin K, vitamin E, phytosterols (anticholeterolemic) , taxol (anticancer agent), natural rubber
Flavonoids and phenylpropanoids	anthocyanins, isoflavones. resveratrol, curcumin (food antioxidants), tannins (leather tanning), coumarins (bioimaging), lignin (wood industry)
Glucosinolates	Sinigrin, glucoraphanin (food flavors)
Cyanogenic glucosides	Amygdalin (defence compound)

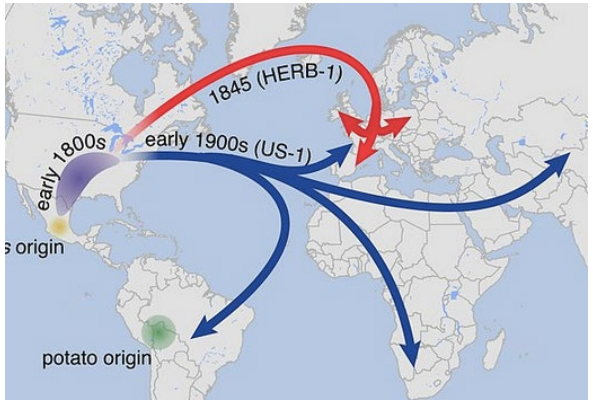
General structure



- Over 1 million different secondary metabolites are synthesized by terrestrial plants
- 20% to 30% of our pharmacopeia is bioinspired from plant metabolites

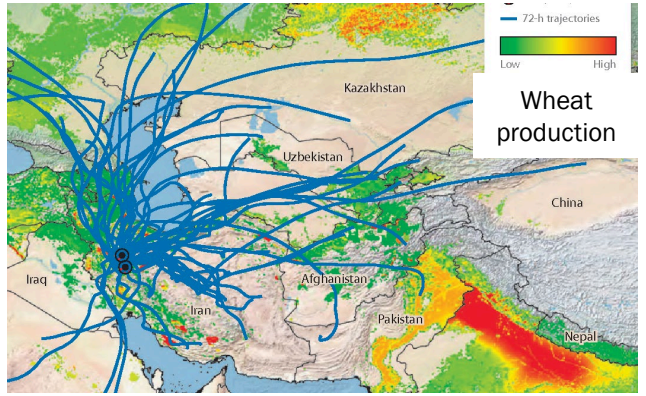
Plant pandemics: past and present of a global threat

The Irish Potato Famine (1845)



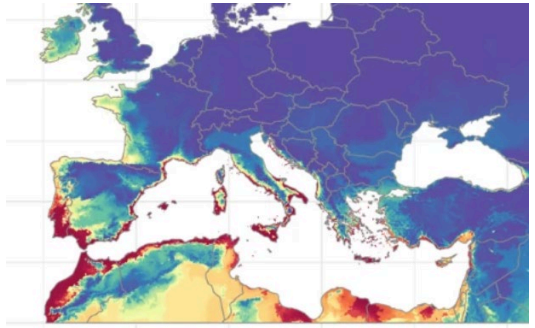
- Caused by *Phytophthora infestans,* a fungus that arrived from an area different from the potato center of origin.
- Reduced Irish potato production by 90% in two years
- Caused **1 million deaths and 1 million migrants** (25% of the total population).

UG99 wheat stem rust (1988)



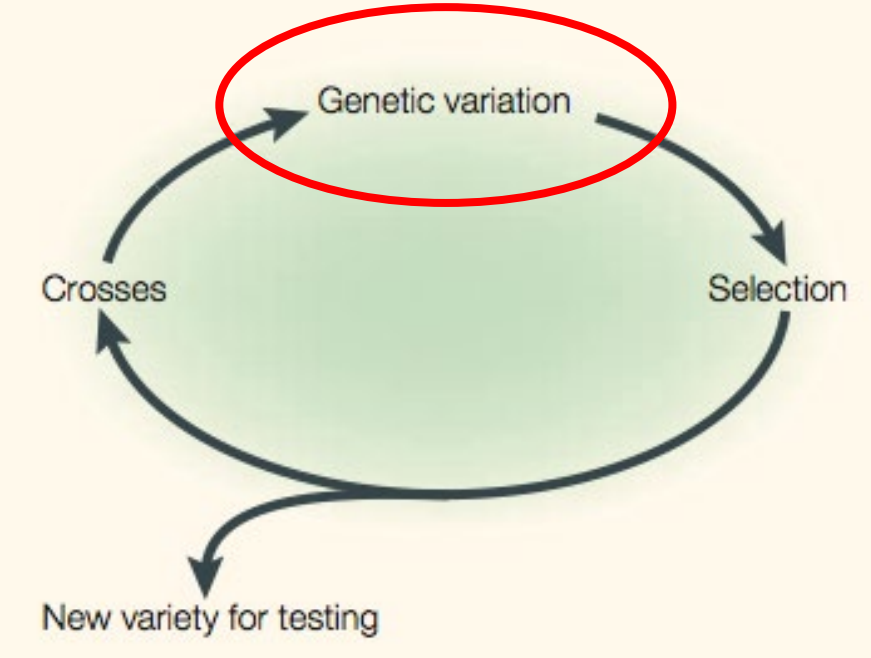
Potential Asian spread routes

Xylella fastidiosa olive syndrome (2013)



Climate-permissive Mediterranean areas

Crop wild relatives and landraces are reservoirs of pathogen resistance genes



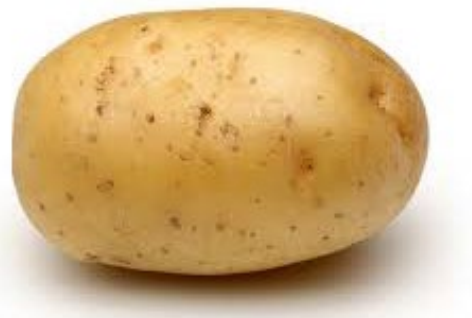
The plant breeding paradigm

(Zamir, 2021)

S. demissum

(potato wild relative)

R gene



Phytophthora-resistant potato

A. sharonensis

(wheat wild relative)

R gene

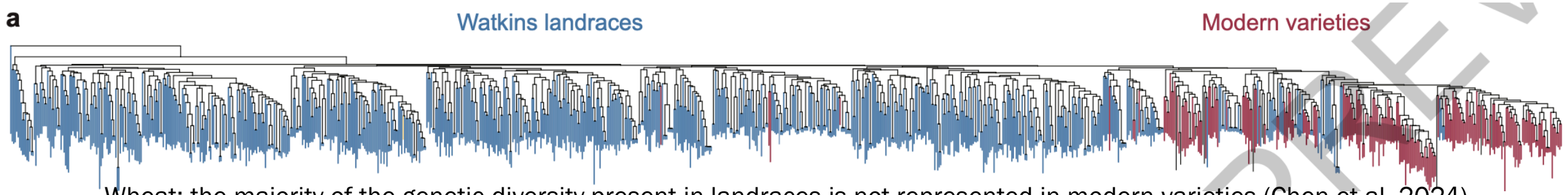
UG99-resistant wheat

R gene

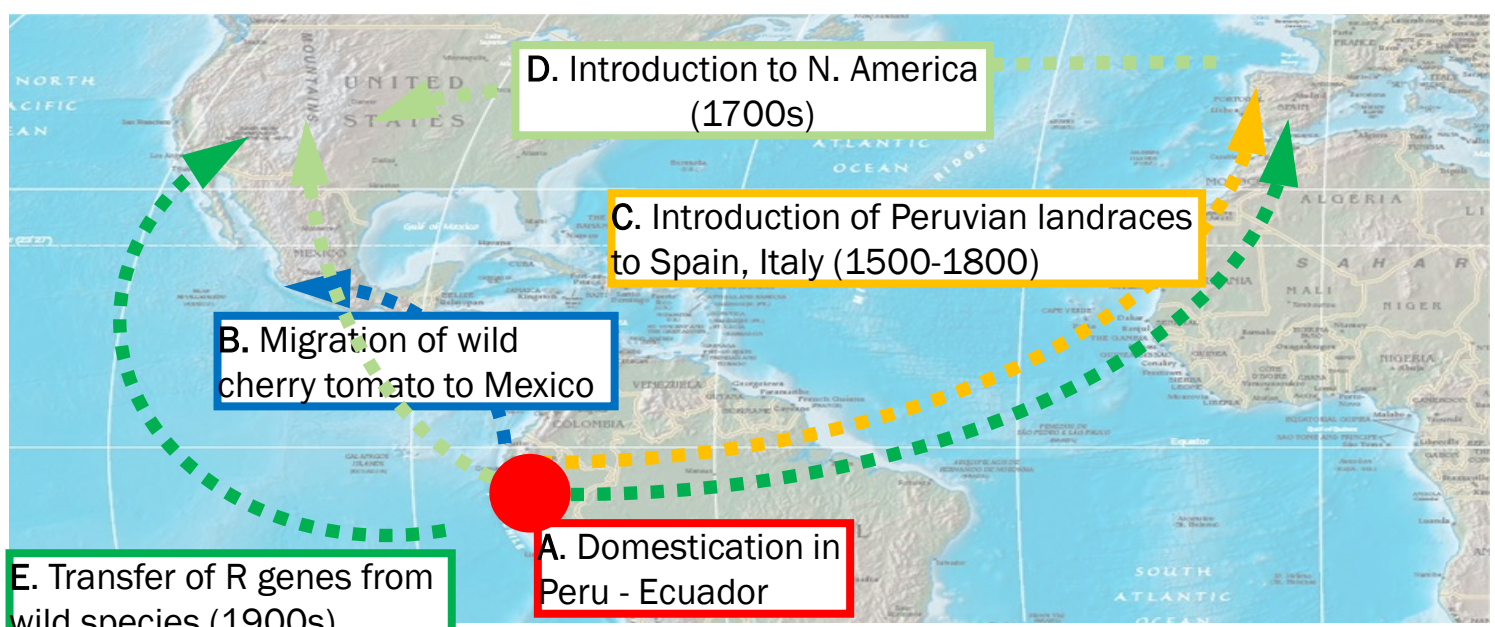
PI 374670

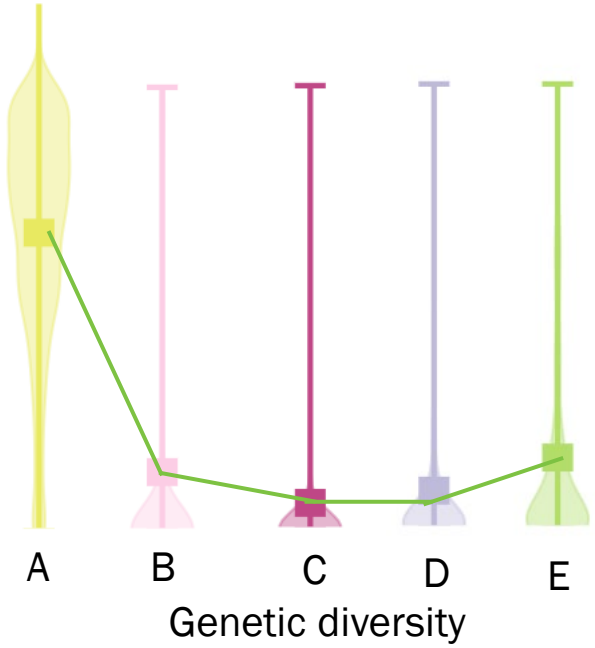
(low yielding wheat landrace)

Loss of genetic diversity during domestication and breeding



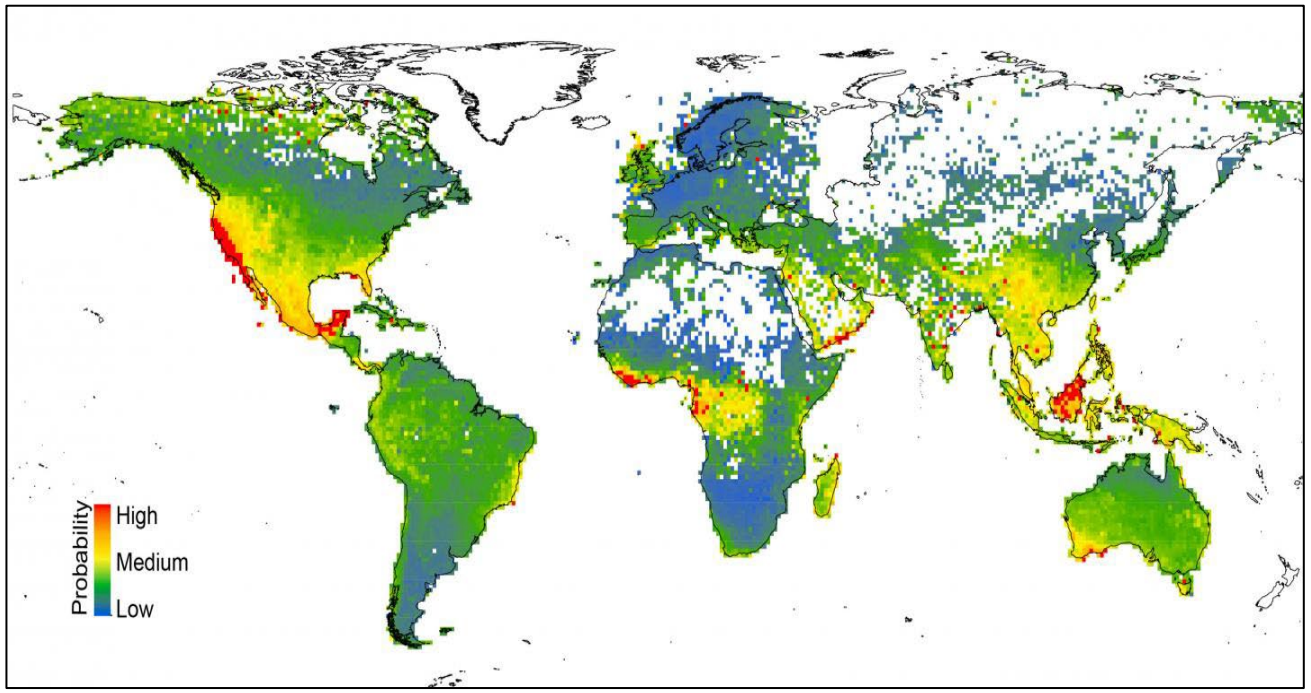
Wheat: the majority of the genetic diversity present in landraces is not represented in modern varieties (Chen et al, 2024)



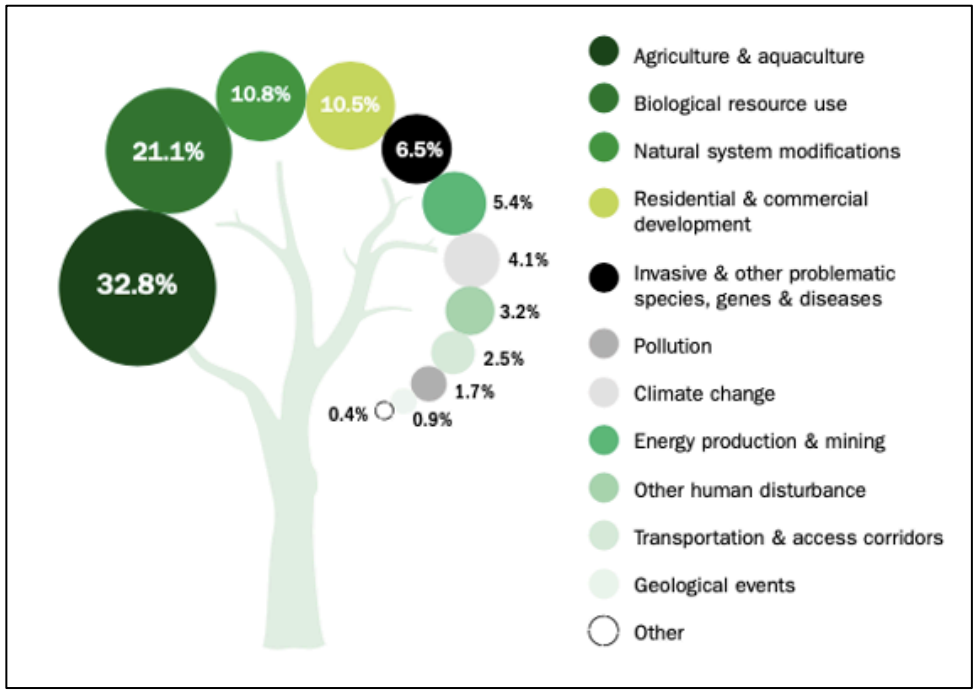


Tomato: the genetic diversity present in early domesticates was lost during migration to Europe and breeding. It was partially regained through trasfer of *R* genes to modern varieties (unpublished).

Loss of biodiversity in the wild



Worldwide distribution of plant species at risk of extinction



Main causes of plant extinction (1)

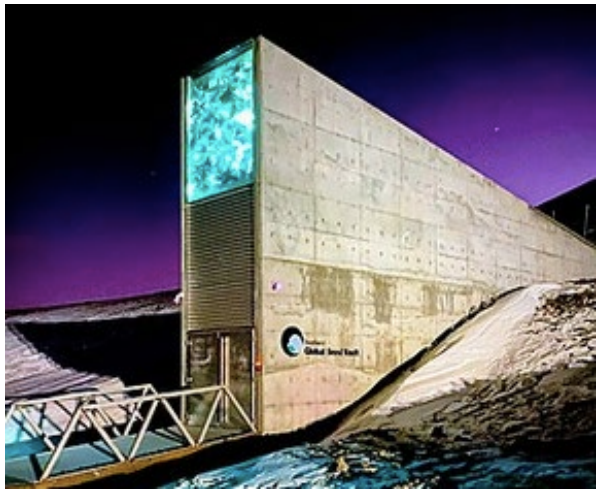
- Around 40% of plant species are at risk of extinction globally.
- This figure fluctuates between 10%-45% for crop wild relatives, and reaches 60% for some groups (cycads, epiphytes, orchids)

(1) Kew Gardens «State of the World's Plants and Fungi»

How to prevent the loss of plant biodiversity

In situ- on farm conservation

Ex situ conservation (Genebanks)



Seed vaults (the last resort)

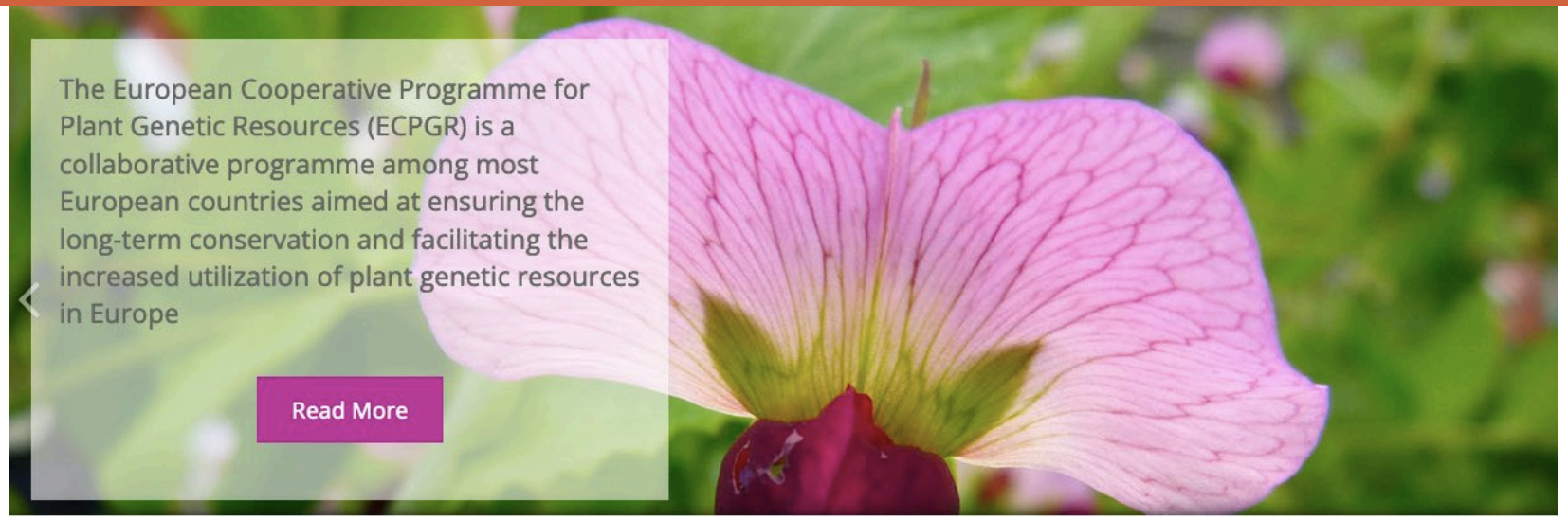
Documentation & access

Safety

- Around 4 M of plant accessions are conserved in worldwide genebanks (1), of which around 2 M in Europe (2)
- The European accessions are spread over 400 different institutions, with dishomogenous management standards
- International regulations, and phytosanitary hurdles prevent the effective exchange of materials
- Active in situ / on-farm population conservation is very limited and does not meet proposed standards (3)

(1) https://www.genesys-pgr.org/ (2) https://eurisco.ipk-gatersleben.de/apex/eurisco_ws/r/eurisco/home
(3) http://www.fao.org/agriculture/seed/sow2/en/

We’re not starting from scratch



European Cooperative Programme for Plant Genetic Resources
ECP/GR

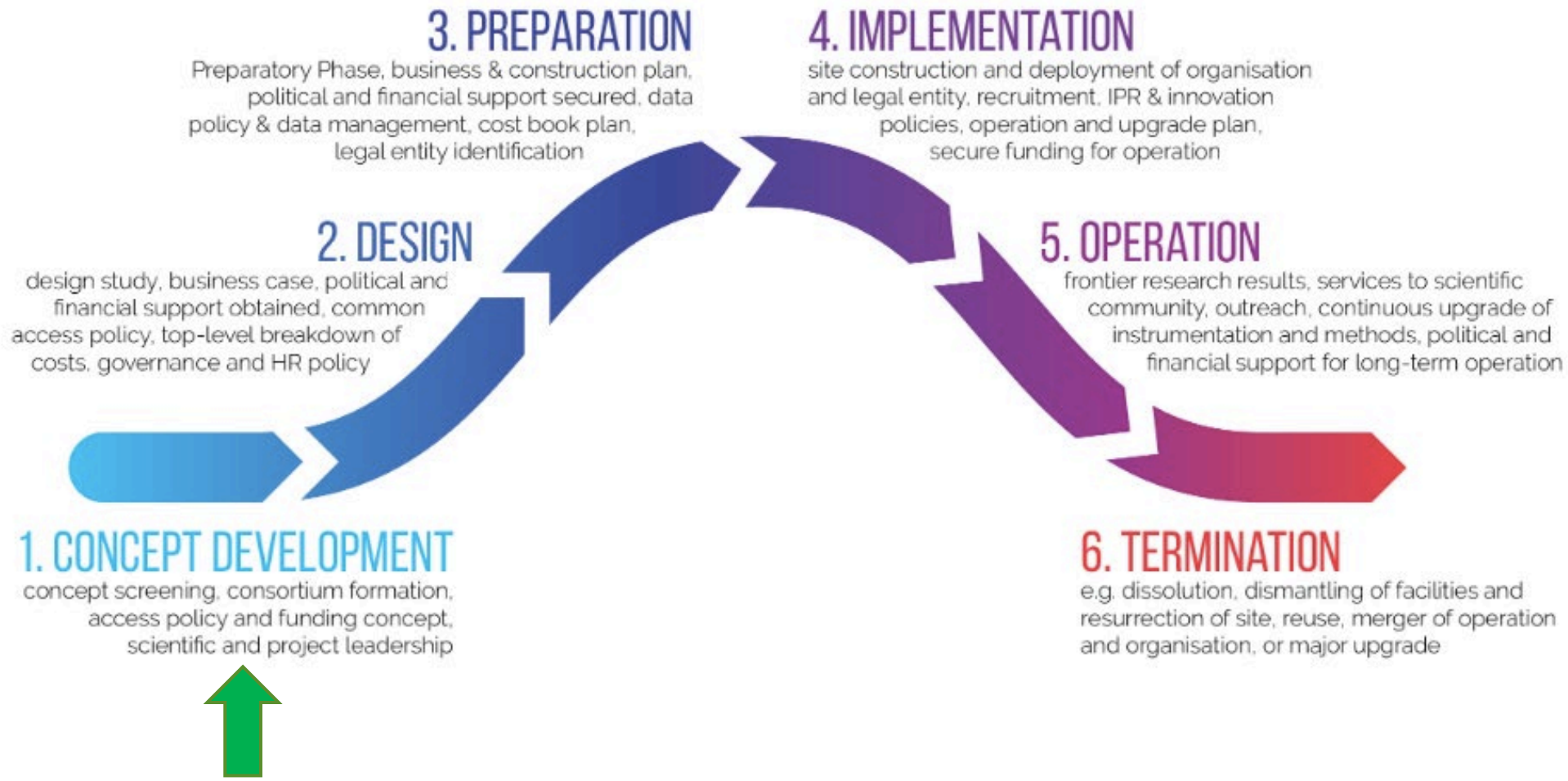
eurisco
Finding seeds for the future

The **European Search Catalogue for Plant Genetic Resources** (EURISCO) provides passport and phenotypic data on **>2 million accessions** of crop plants and their wild relatives, preserved *ex situ* by about **400 institutes** from **43 member countries**.

>10 EU-funded projects have generated novel genetic resources and associated knowledge and methods on important crop plant families (Cereals, Solanaceae, Legumes).

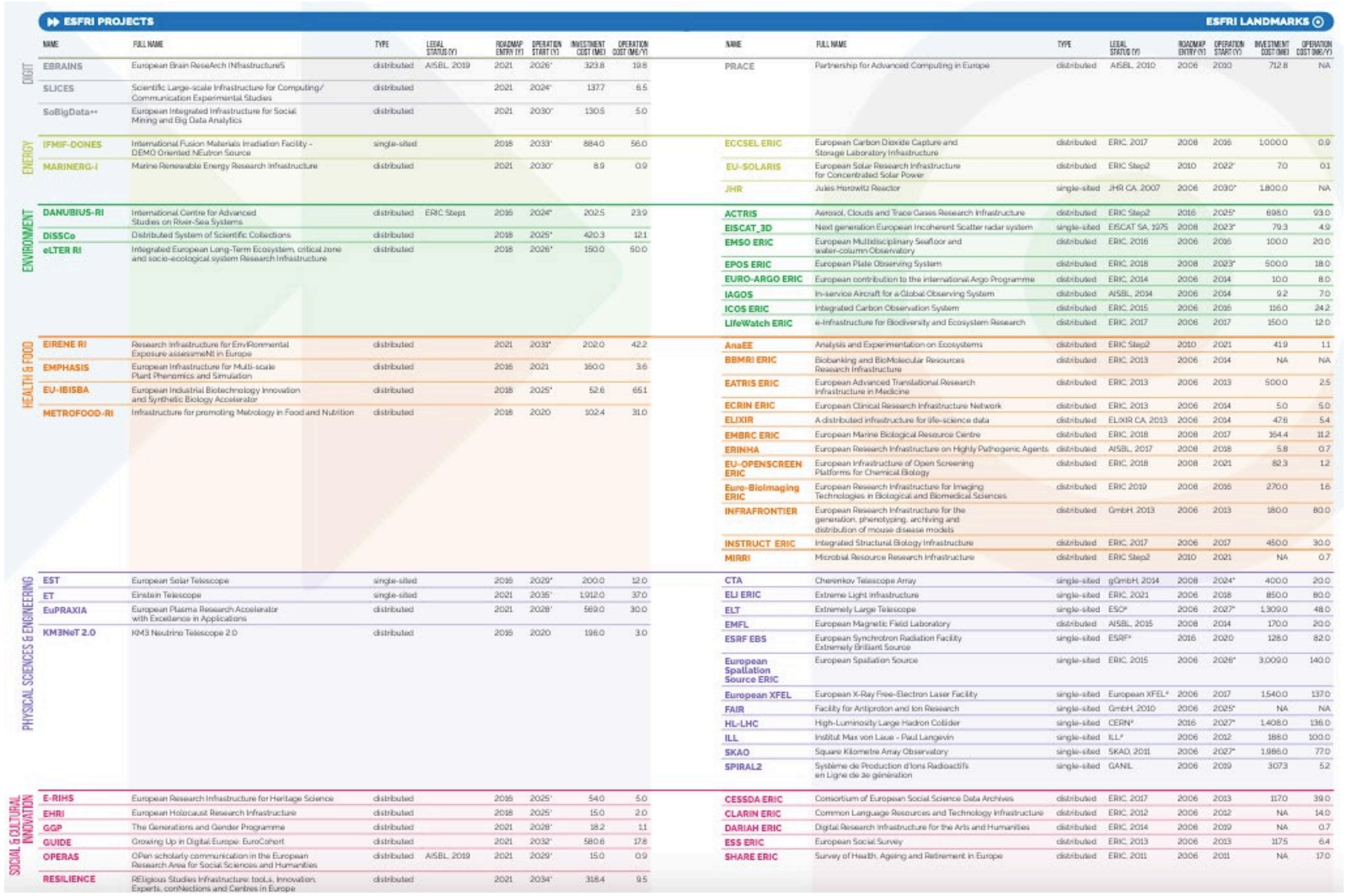
TRADITOM
AGENT
FORGENIUS
G2P-SOL
INCREASE
Farmer’s Pride
Breeding Value
HARNESSTOM
GEN4OLIVE

The life cycle of an ESFRI Research Infrastructure



PRO-GRACE

Europe funds a series of Research Infrastructures...



ESFRI PROJECTS

	NAME	FULL NAME	TYPE	LEGAL STATUS (Y)	ROADMAP ENTRY (Y)	OPERATION START (Y)	INVESTMENT COST (M€)	OPERATION COST (M€/Y)
DIGIT	EBRAINS	European Brain ReseArch INfrastructureS	distributed	AISBL 2019	2021	2026*	323.8	19.8
	SLICES	Scientific Large-scale Infrastructure for Computing/Communication Experimental Studies	distributed		2021	2024*	137.7	8.5
	SoBigData++	European Integrated Infrastructure for Social Mining and Big Data Analytics	distributed		2021	2030*	130.5	5.0
ENERGY	IFMIF-DONES	International Fusion Materials Irradiation Facility – DEMO Oriented NEutron Source	single-sited		2018	2033*	884.0	56.0
	MARINERG-I	Marine Renewable Energy Research Infrastructure	distributed		2021	2030*	8.9	0.9
ENVIRONMENT	DANUBIUS-RI	International Centre for Advanced Studies on River-Sea Systems	distributed	ERIC Step1	2016	2024*	202.5	23.9
	DISSCo	Distributed System of Scientific Collections	distributed		2018	2025*	420.3	12.1
	eLTER RI	Integrated European Long-Term Ecosystem, critical zone and socio-ecological system Research Infrastructure	distributed		2018	2026*	150.0	50.0
HEALTH & FOOD	EIRENE RI	Research Infrastructure for EnviRonmental Exposure assessmeNt in Europe	distributed		2021	2031*	202.0	42.2
	EMPHASIS	European Infrastructure for Multi-scale Plant Phenomics and Simulation	distributed		2016	2021	160.0	3.6
	EU-IBISBA	European Industrial Biotechnology Innovation and Synthetic Biology Accelerator	distributed		2018	2025*	52.6	65.1
	METROFOOD-RI	Infrastructure for promoting Metrology in Food and Nutrition	distributed		2018	2020	102.4	31.0
PHYSICAL SCIENCES & ENGINEERING	EST	European Solar Telescope	single-sited		2016	2029*	200.0	12.0
	ET	Einstein Telescope	single-sited		2021	2035*	1,912.0	37.0
	EuPRAXIA	European Plasma Research Accelerator with Excellence in Applications	distributed		2021	2028*	569.0	30.0
	KM3NeT 2.0	KM3 Neutrino Telescope 2.0	distributed		2016	2020	198.0	3.0
SOCIAL & CULTURAL INNOVATION	E-RIHS	European Research Infrastructure for Heritage Science	distributed		2016	2025*	54.0	5.0
	EHRI	European Holocaust Research Infrastructure	distributed		2018	2025*	15.0	2.0
	GGP	The Generations and Gender Programme	distributed		2021	2028*	18.2	1.1
	GUIDE	Growing Up in Digital Europe: EuroCohort	distributed		2021	2032*	580.6	17.8
	OPERAS	OPen scholarly communication in the European Research Area for Social Sciences and Humanities	distributed	AISBL 2019	2021	2029*	15.0	0.9
	RESILIENCE	REligious Studies Infrastructure: tool.s, Innovation, Experts, conNections and Centres in Europe	distributed		2021	2034*	318.4	9.5

ESFRI LANDMARKS

NAME	FULL NAME	TYPE	LEGAL STATUS (Y)	ROADMAP ENTRY (Y)	OPERATION START (Y)	INVESTMENT COST (M€)	OPERATION COST (M€/Y)
PRACE	Partnership for Advanced Computing in Europe	distributed	AISBL 2010	2006	2010	712.8	NA
ECCSEL ERIC	European Carbon Dioxide Capture and Storage Laboratory Infrastructure	distributed	ERIC 2017	2008	2016	1,000.0	0.9
EU-SOLARIS	European Solar Research Infrastructure for Concentrated Solar Power	distributed	ERIC Step2	2010	2022*	7.0	0.1
JHR	Jules Horowitz Reactor	single-sited	JHR CA 2007	2006	2030*	1,800.0	NA
ACTRIS	Aerosol, Clouds and Trace Gases Research Infrastructure	distributed	ERIC Step2	2016	2025*	698.0	93.0
EISCAT_3D	Next generation European Incoherent Scatter radar system	single-sited	EISCAT SA 1975	2008	2023*	79.3	4.9
EMSO ERIC	European Multidisciplinary Seafloor and water-column Observatory	distributed	ERIC 2018	2006	2016	100.0	20.0
EPOS ERIC	European Plate Observing System	distributed	ERIC 2018	2008	2023*	500.0	18.0
EURO-ARGO ERIC	European contribution to the international Argo Programme	distributed	ERIC 2014	2006	2014	10.0	8.0
IAGOS	In-service Aircraft for a Global Observing System	distributed	AISBL 2014	2006	2014	9.2	7.0
ICOS ERIC	Integrated Carbon Observation System	distributed	ERIC 2015	2006	2016	116.0	24.2
LifeWatch ERIC	e-Infrastructure for Biodiversity and Ecosystem Research	distributed	ERIC 2017	2006	2017	150.0	12.0
AnaEE	Analysis and Experimentation on Ecosystems	distributed	ERIC Step2	2010	2021	41.9	1.1
BBMRI ERIC	Biobanking and BioMolecular Resources Research Infrastructure	distributed	ERIC 2013	2006	2014	NA	NA
EATRIS ERIC	European Advanced Translational Research Infrastructure in Medicine	distributed	ERIC 2013	2006	2013	500.0	2.5
ECRIN ERIC	European Clinical Research Infrastructure Network	distributed	ERIC 2013	2006	2014	5.0	5.0
ELIXIR	A distributed infrastructure for life-science data	distributed	ELIXIR CA 2013	2006	2014	47.6	5.4
EMBRC ERIC	European Marine Biological Resource Centre	distributed	ERIC 2018	2008	2017	164.4	11.2
ERINHA	European Research Infrastructure on Highly Pathogenic Agents	distributed	AISBL 2017	2006	2018	5.8	0.7
EU-OPENSCREEN ERIC	European Infrastructure of Open Screening Platforms for Chemical Biology	distributed	ERIC 2018	2008	2021	82.3	1.2
Euro-BioImaging ERIC	European Research Infrastructure for Imaging Technologies in Biological and Biomedical Sciences	distributed	ERIC 2019	2008	2016	270.0	1.6
INFRAFRONTIER	European Research Infrastructure for the generation, phenotyping, archiving and distribution of mouse disease models	distributed	GmbH 2013	2006	2013	180.0	80.0
INSTRUCT ERIC	Integrated Structural Biology Infrastructure	distributed	ERIC 2017	2006	2017	450.0	30.0
MIRRI	Microbial Resource Research Infrastructure	distributed	ERIC Step2	2010	2021	NA	0.7
CTA	Cherenkov Telescope Array	single-sited	gGmbH 2014	2008	2024*	400.0	20.0
ELI ERIC	Extreme Light Infrastructure	single-sited	ERIC 2021	2006	2018	850.0	80.0
ELT	Extremely Large Telescope	single-sited	ESO*	2006	2027*	1,309.0	48.0
EMFL	European Magnetic Field Laboratory	distributed	AISBL 2015	2008	2014	170.0	20.0
ESRF EBS	European Synchrotron Radiation Facility Extremely Brilliant Source	single-sited	ESRF*	2016	2020	128.0	82.0
European Spallation Source ERIC	European Spallation Source	single-sited	ERIC 2015	2006	2026*	3,000.0	140.0
European XFEL	European X-Ray Free-Electron Laser Facility	single-sited	European XFEL*	2006	2017	1,540.0	137.0
FAIR	Facility for Antiproton and Ion Research	single-sited	GmbH 2010	2006	2025*	NA	NA
HL-LHC	High-Luminosity Large Hadron Collider	single-sited	CERN*	2016	2027*	1,408.0	136.0
ILL	Institut Max von Laue - Paul Langevin	single-sited	ILL*	2006	2012	188.0	100.0
SKAO	Square Kilometre Array Observatory	single-sited	SKAO 2011	2006	2027*	1,986.0	77.0
SPIRAL2	Système de Production d'Ions Radioactifs en Ligne de 2e génération	single-sited	GANIL	2006	2019	307.3	5.2
CESSDA ERIC	Consortium of European Social Science Data Archives	distributed	ERIC 2017	2006	2013	117.0	39.0
CLARIN ERIC	Common Language Resources and Technology Infrastructure	distributed	ERIC 2012	2006	2012	NA	14.0
DARIAH ERIC	Digital Research Infrastructure for the Arts and Humanities	distributed	ERIC 2014	2006	2029	NA	0.7
ESS ERIC	European Social Survey	distributed	ERIC 2013	2006	2013	11.5	6.4
SHARE ERIC	Survey of Health, Ageing and Retirement in Europe	distributed	ERIC 2011	2006	2011	NA	17.0

www.esfri.eu

...but none of them is dedicated to the conservation and improvement of the plants that feed humanity

Key messages for the future GRACE-RI 1

•Plants are essential for the survival of humanity and of the maintenance of healthy ecosystems.

•We are on the brink of the 6th large extinction on this planet. Both species and their genetic diversity are threatened. Terrestrial plants are particularly at risk. The upcoming crisis will be global, not local.

•Climate change, emerging pathogens, water scarcity and overpopulation will increasingly require the breeding of novel, resilient food plant varieties.

•Therefore, PGRs should be considered a heritage for future generations. They need to be effectively conserved and made freely available for use, with clear rules on reciprocity and benefit sharing.

Key messages for the future GRACE-RI 2

- No EU Research Infrastructure presently addresses the study, conservation and valorization of PGRs.
- The GRACE-RI will have a large impact on several important economic sectors: seed production, agriculture, and the plant-derived bioeconomy.
- The GRACE-RI will contribute, directly or indirectly, to the following UN sustainable development goals: zero hunger, good health and well-being, life on land, decent work and economic growth, and partnerships.
- These problems can only be tackled through a Europe-wide (and, in perspective, global) infrastructure on research, conservation, and utilization of PGRs.

We need a paradigm shift, and we need it now

Research community

Agricultural sector

PGR conservation community

GRACE RI

UN sustainable development goals

Plant breeding community

Plant-based bioproducts

Ancient Greeks depicted Kairos (the right occasion or moment) as a young man with wings, long hair on the forehead and shaved on the back. It meant that either you catch it when it's coming towards you, or once it has passed by, it's too late.

Thank you for your attention!

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