Possiamo conservare la diversità genetica non conoscendola?

L'importanza dell'indagine genetica per la vivaistica forestale

Andrea Piotti

Consiglio Nazionale delle Ricerche

ibbr

Seeds of Hope.

Sprucing up forest restoration with genomics

Anoob Prakash[1], Department of Plant Biology, University of Vermont
Stephen R. Keller*, Department of Plant Biology, University of Vermont
*Contact info | email: [1]ap1@uvm.edu, *srkeller@uvm.edu

Highlights

- Global anthropogenic change threatens the health and productivity of forest ecosystems.
- Assisted migration and reforestation are tools to help mitigate these impacts.
- Genomics informed approach to assist in decisions regarding seed source selection for restoration.
- Pooling of multiple seed sources with higher genetic diversity and lower genetic load is a better alternative to identifying a single super source for reforestation.

learn more here

Study system: Red spruce (*Picea rubens*)

- Temperate coniferous tree species that has experienced widespread decline due to anthropocenic causes since the late 19th century.
- Prime example of a tree species vulnerable to rapid changes in the climate due to its isolated populations and limited within-population genetic diversity in the southern part of its range.[1,2]

Seed sources pooled and selected for high genetic diversity and low genetic load for early life fitness

Whole-exome capture sequencing was used to profile the genomic diversity of potential seed sources for restoration.

The full dataset consists of sequenced exomes for 339 individuals sampled from across the species range.[1]

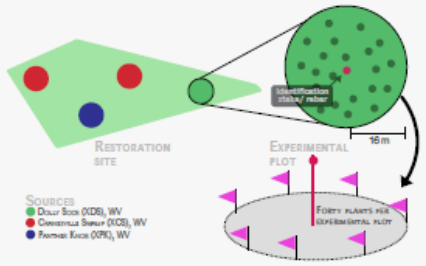
Genetic diversity (GD) was estimated based on expected heterozygosity across all single nucleotide polymorphisms (SNPs), which provides a fundamental measure of genetic variation based on the frequency of heterozygous genotypes expected under Hardy-Weinberg equilibrium[2].

Genetic load (GL) measures the accumulation of deleterious mutations in the population due to genetic drift. GL was calculated as the number of non-synonymous SNPs (P_N) and the number of synonymous (silent) SNPs (P_S), weighted by their corresponding frequencies (F_N and F_S).

$$GL = P_N F_N / P_S F_S$$

Calculated under the well-supported assumption that the majority of nonsynonymous mutations are deleterious[3].

Experimental design



Over 58 thousand red spruce seedlings planted in 2021

Under the regional admixture provenancing framework[1], seed sources local to the restoration site were selected.

Pooled sources with high GD and low GL were selected for restoration.

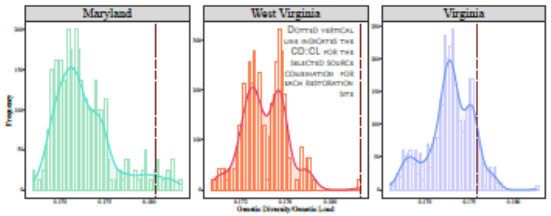
Experimental framework

The monitoring protocol was initiated at the time of planting to track establishment success.

The monitoring design consisted of geo-referenced experimental plots stratified by seed source in order to assess the single source variability at each site.

Survivorship post one-year of planting was >50% across three restoration sites

GD:GL for the source combinations selected for each restoration site



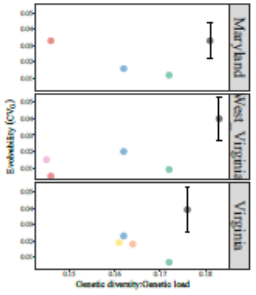
Coefficient of Evolvability to analyse the effects of source selection on the evolutionary potential of trait variance

$$CV_G = \sqrt{V_G} / \bar{x}$$

Evolvability[4] was measured on the trait variance of the seedling height post one-year of planting in the field.

Evolvability helps analyze the effect of single vs pooled sources on the evolutionary potential of trait variance in the restored populations.

Evolvability for different sources planted at each restoration site and the bootstrapped pooled CV_G for source combinations at each site. The x-axis shows the GD:GL estimates for the singular and pooled sources.



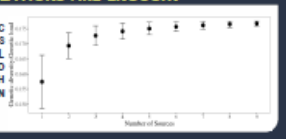
NO super source to the rescue

Pooled seed sources exhibited higher evolvability compared to singular seed sources across the restoration sites

- The longer term benefit of regional admixture strategy will likely manifest from the offspring of these restoration plantings.
- The mating between the offspring holds the potential to recombine their genetic variation and increase the adaptive potential to respond to changing environments.

How many populations are enough?

The benefit of choosing multiple seed sources to maximize GD:GL flattens out around 4-5 sources, with diminishing returns on higher combinations.



What does this all mean for our planet?

The Central Appalachian Spruce Restoration Initiative (CASRI) members have worked for years to restore red spruce through experimental planting and silvicultural treatments, this is the first time seed sources were selected based on genetics.

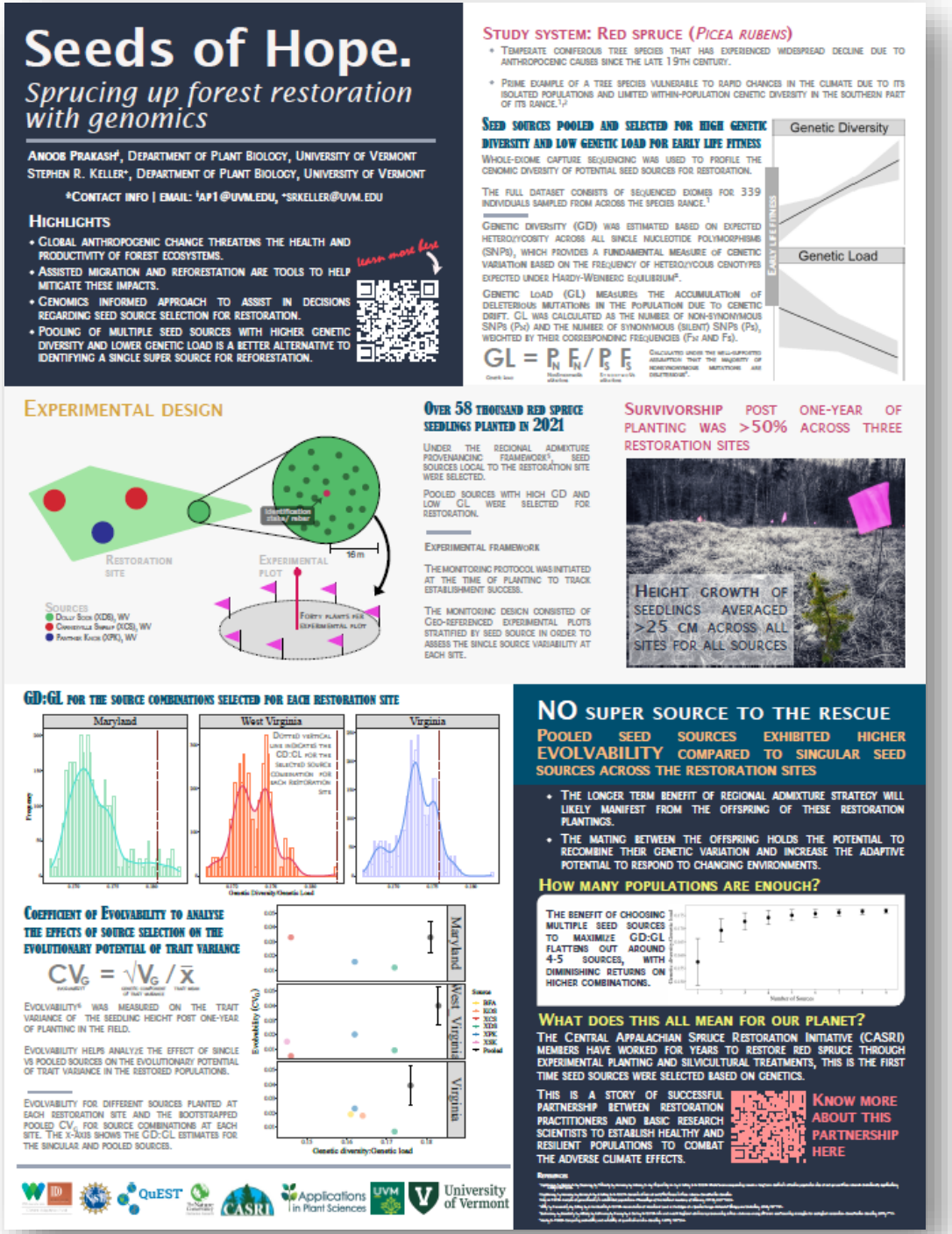
This is a story of successful partnership between restoration practitioners and basic research scientists to establish healthy and resilient populations to combat the adverse climate effects.

Know more about this partnership here

References

QuEST · CASRI · Applications in Plant Sciences · University of Vermont

Seeds of hope -> i semi della speranza



Seeds of hope -> i semi della speranza

<u>Controllo sulle caratteristiche genetiche</u>

Elevata diversità genetica

Basso frequenza mutazioni deleterie

<u>Miglioramento delle performance</u>

Potenzialità di adattamento da 3× a 8×

->->-> *Restoration genomics*

Prakash *et al*. 2024 Applications in Plant Sciences

Forest@
Rivista di Selvicoltura ed Ecologia Forestale

Commenti & Prospettive
doi: 10.3832/efor4193-019
vol. 19, pp. 85-94

La vivaistica forestale in Italia al bivio: sfide e strategie

Barbara Mariotti [1-13],
Giustino Mezzalira [2-13],
Enrico Allasia [3-13],
Francesco Fazio [4-13],
Roberto Fiorentin [2-13],
Alberto Maltoni [1-13],
Marco Marchetti [5-13],
Giorgio Matteucci [6-13],
Paolo Mori [7-13],
Renzo Motta [8-13],
Andrea Piotti [9-13],
Angela Rositi [10-13],
Maurizio Sabatti [11-13],
Roberto Tognetti [12-13],
Fabio Salbitano [1-13]

The Italian forest nursery sector at the crossroads: challenges and strategies

The recognition of the key role of forests in contrasting the dramatic effects of climate change and biodiversity crisis is the pillar of many initiatives on a global, European, and national scale calling for afforestation campaigns. The Italian forest nursery sector is currently inadequate to meet the demand for tree seedlings for the national campaigns. Forest nursery production is characterized by regional or local companies that are remarkably different from each other in organization and efficiency. It is therefore urgent to develop a comprehensive restructuring of the entire sector to be able to respond to the specific needs of forestry projects in Italy and Europe. In this paper, we present a series of key principles and criteria aimed at guiding the renaissance of the sector. Strategic actions are proposed by integrating research, governance, public/private partnership, training, and communication. The strategic approach presented is based on a collaborative structure integrating various skills and responsibilities. The first step is an expert review of the Basic Materials (BM) included in the National Register thanks to the development of the genetic studies of forest stands and the inclusion of shrub and herbaceous species, essentials for ecosystem restoration projects counteracting the biodiversity crisis. A series of actions concerns the aspects of certification, voluntary

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DATAROOM

Corriere.it
Guardate i video sul sito del «Corriere della Sera» nella sezione Dataroom con gli approfondimenti di data journalism

di **Milena Gabanelli** e **Gianni Santucci**

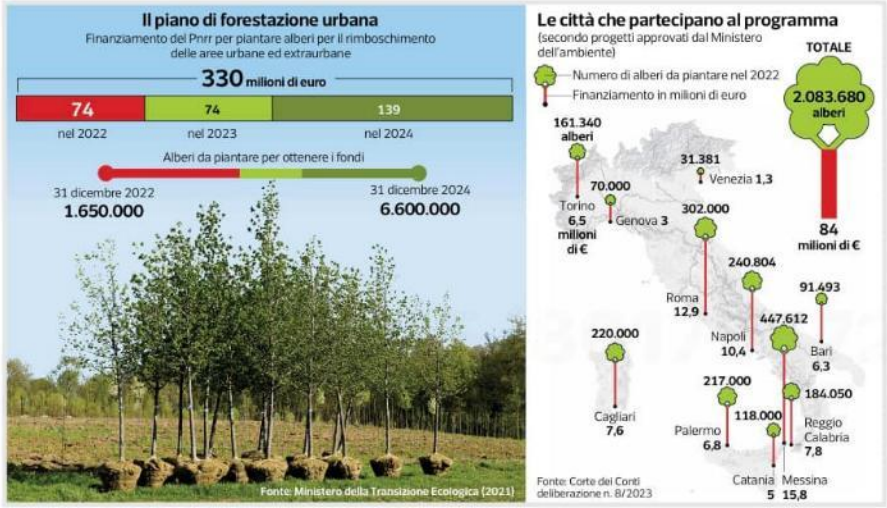
L'inganno degli alberi sui finanziamenti Ue

I CONTROLLI DI CORTE DEI CONTI E CARABINIERI: PIANTATI SOLO SEMI COSÌ SONO A RISCHIO I 330 MILIONI DI FONDI PER 6,6 MILIONI DI PIANTE L'OBIETTIVO È COMBATTERE SMOG E CALORE INTORNO ALLE CITTÀ

L'Europa ci finanzia (tanto: 330 milioni) per piantare nuovi alberi intorno alle città (tantissimi: 6 milioni e 600 mila piante). L'Italia però, per ora, sta mettendo in terra soltanto dei semi. Secondo il collegio di controllo concomitante della Corte dei conti, l'equiparazione non sta in piedi. I carabinieri, incaricati delle verifiche, sostengono la stessa tesi: non possono «collaudare» progetti di forestazione urbana senza vedere gli alberi. E così, se l'equivalenza albero-seme ipotizzata dal ministero dell'Ambiente non verrà accettata dalla Commissione europea, l'Italia rischia di disperdere la possibilità offerta dal Piano nazionale di ripresa e resilienza: creare nuovi boschi intorno alle 14 Città metropolitane per combattere l'inquinamento (abbiamo tre procedure di infrazione aperte) e contrastare l'effetto «isola di calore» in estate.

I requisiti del bando

Il documento da cui partire è l'avviso pubblico per aderire ai bandi del Pnrr. Risale al 30 marzo 2022. Il piano riservato alle Città è articolato in 3 anni: 74 milioni nel 2022, per piantare almeno un milione e 650 mila alberi entro l'anno, ovvero 1.700 ettari di bo-



AlberItalia

RI-VIVA-FOR

Manifesto per il rilancio delle attività vivaistiche in Italia

ANARF

SISEF

Azioni strategiche

Ricerca e Sviluppo

- Aggiornare Materiali forestali di Base iscritti nel Registro Nazionale
- Promuovere le migliori tecniche di coltivazione in accordo con le Linee Guida del MIPAAF
- * Migliorare e monitorare le conoscenze dei popolamenti
- Includere le specie arbustive ed erbacee
- * Caratterizzare geneticamente i popolamenti forestali
- * Sviluppare linee guida per la raccolta e conservazione delle sementi

Governance

- Promuovere sistemi di certificazione della qualità della vivaistica
- Sviluppare una piattaforma online (*Rete dei Materiali di Base*)
- Creare centri interregionali per la raccolta e conservazione del seme
- Controllo della diffusione e commercializzazione del materiale di propagazione
- *Predisporre policy briefs* per ogni Azione Strategica del Manifesto

Partenariato attivo

- Creare strumenti di *partnership* con il settore vivaistico privato.
- Consolidare la concertazione tra settore pubblico e privato
- Sviluppare sistemi di certificazione volontaria
- Creare un Portale Nazionale delle sementi e delle piantine

Formazione e Comunicazione

- Implementare la formazione del personale e dei dirigenti della filiera
- Creare percorsi formativi di alto livello nelle Università e nelle scuole secondarie professionali
- Sviluppare piani di comunicazione delle informazioni scientificamente fondate e tecnicamente corrette

www.alberitalia.it

21-11-2022
Pagina 1+8/9
Foglio 2 / 5

Il Sole 24 ORE

Quotidiano

Piantati 2,5 milioni di alberi Dote verde per l'ecosistema

21-11-2022
Pagina 1+8/9
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Il Sole 24 ORE

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www.ecostampa.it

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3 BILLION TREES BY 2030

July 2021
#EUForests
#EUGreenDeal

Under the European Green Deal, the EU Biodiversity Strategy commits to **plant at least 3 billion additional trees in the EU by 2030**. **A roadmap** in the EU Forest Strategy outlines how the Commission will facilitate the achievement of this pledge.

TREE PLANTING SHOULD NOT BE SEEN AS AN ALTERNATIVE TO PRESERVING EXISTING TREES, WHICH REMAINS THE FIRST PRIORITY, BUT AS AN ADDITIONAL EFFORT TO INCREASE TREE COVER IN THE EU

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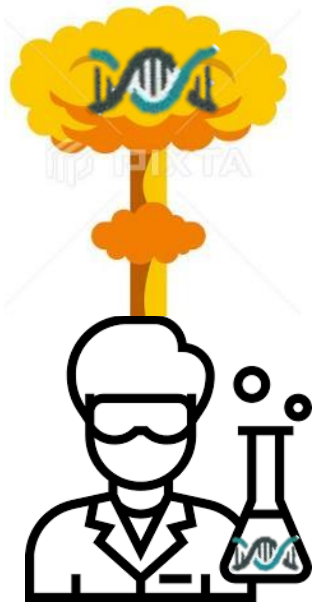
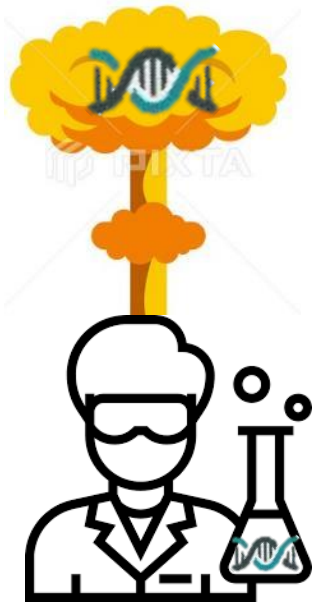
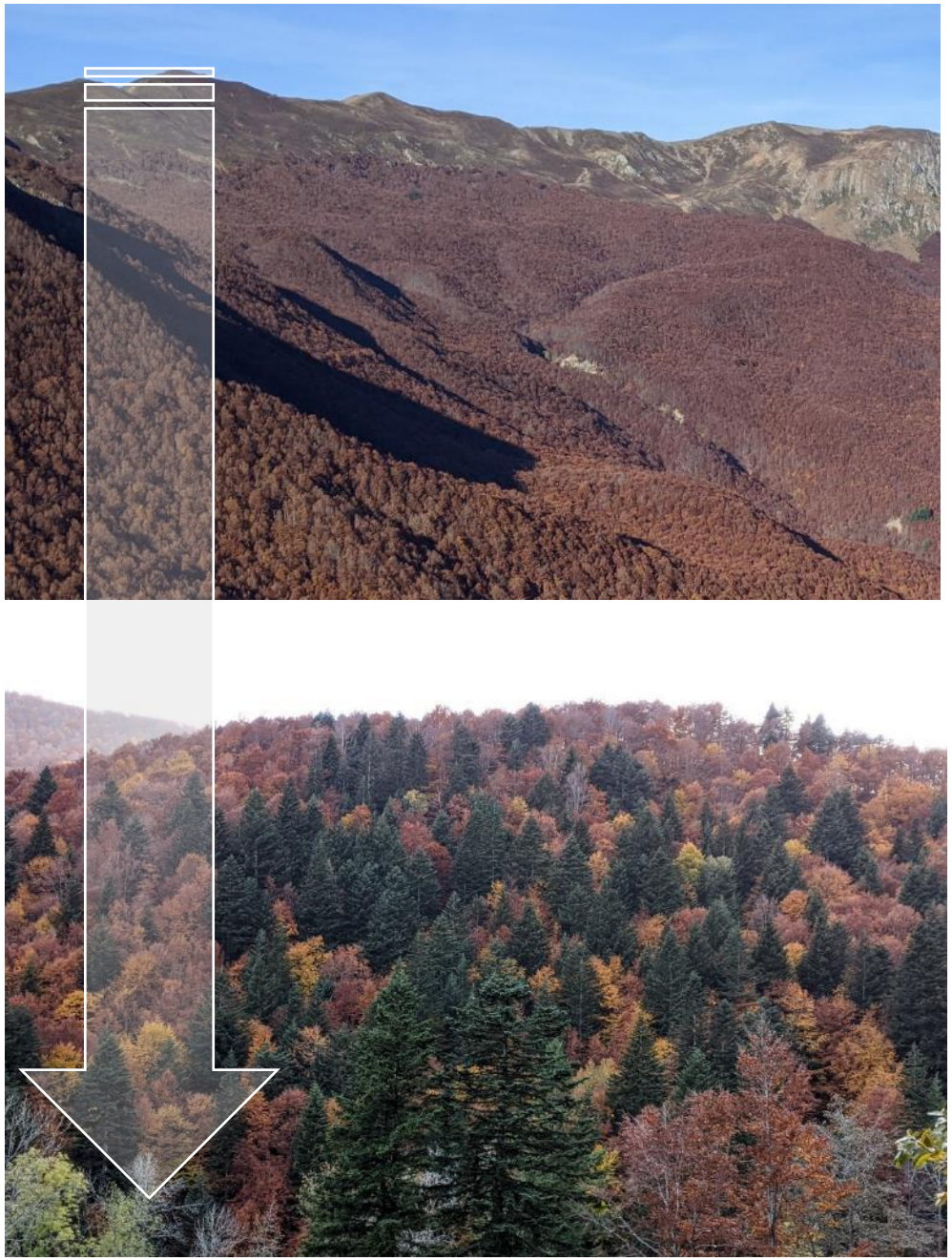
...qualunque albero va bene...

...piantate quello che vi pare dove vi pare...



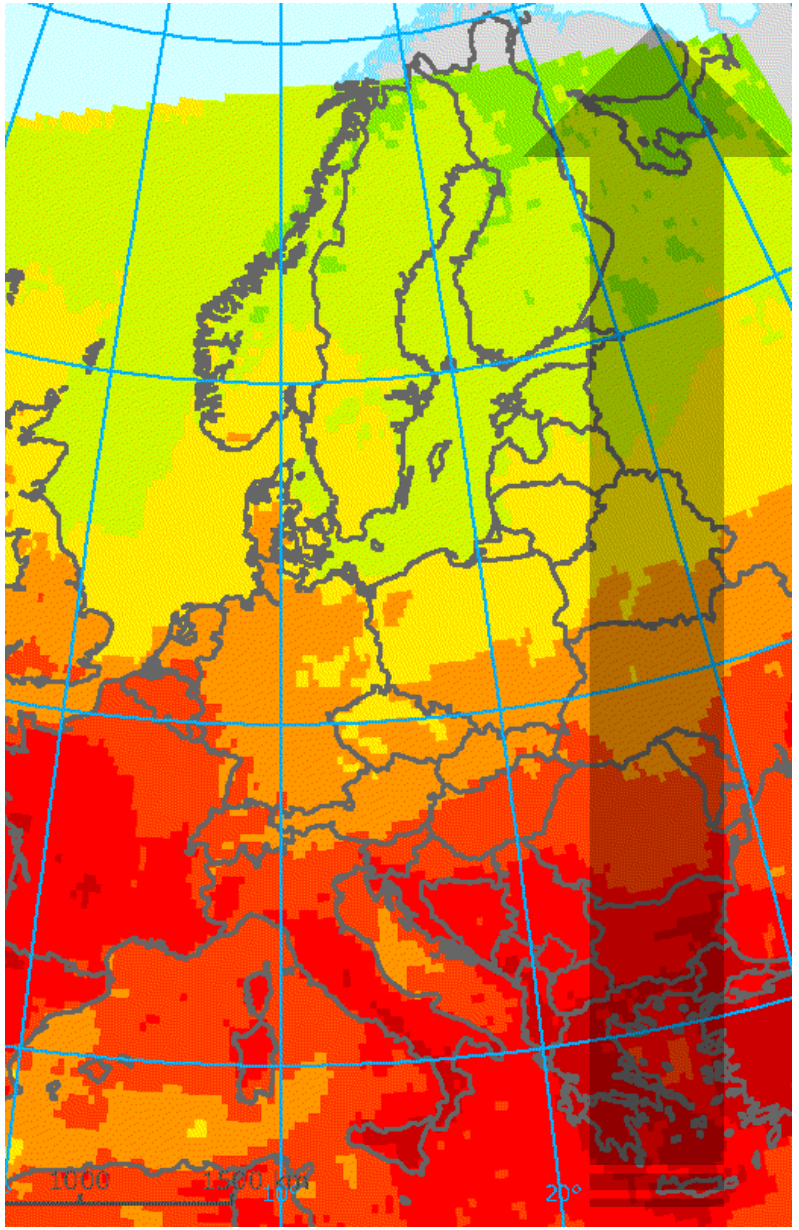


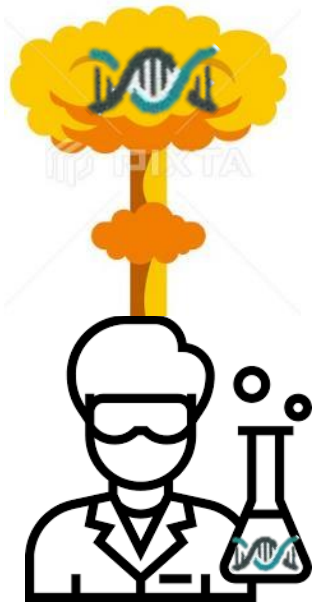
Since 2018, more than **300,000 hectares** of Germany's trees—more than **2.5% of the country's total forest area**—have died because of beetles and drought fueled by a warming climate. **The massive dieback has shocked the public**.



The idea of leaving forests alone alarms other researchers. They argue the climate is changing so quickly that, without human help, even many native trees won't survive in places where they've long thrived. "**We have beeches dying now**, we have maples dying … and pines that were considered pretty drought tolerant,"

«Hartmann, meanwhile, urges researchers to **exploit the genetic diversity hidden within European tree species**.
Pines, for example, grow across much of the continent, and **trees from hotter, drier areas—such as southern Europe—might have already evolved resistance** to conditions forecast for Germany and other more northerly nations»

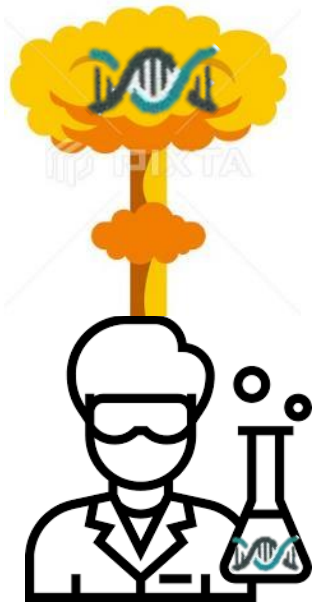




Piantare qualunque albero è la scelta giusta?

Piantare le provenienze locali è la scelta giusta?

Traslocare provenienze che si trovano 1000 km più a sud è la scelta giusta?



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Adattamento genetico locale

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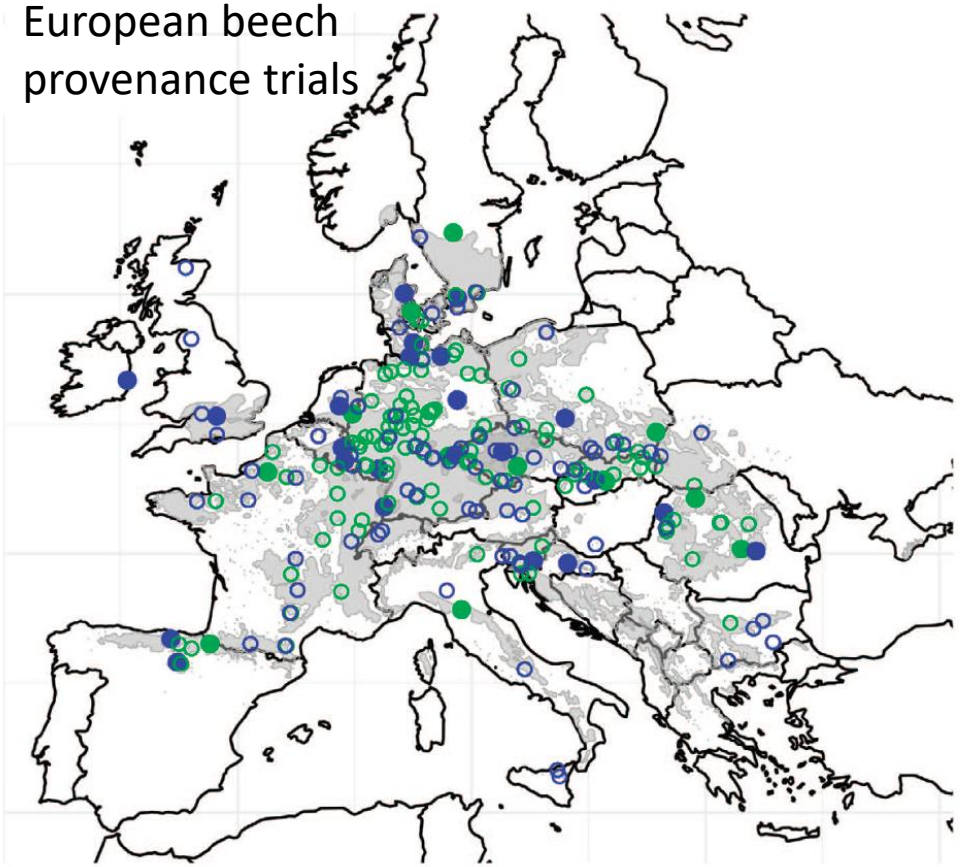
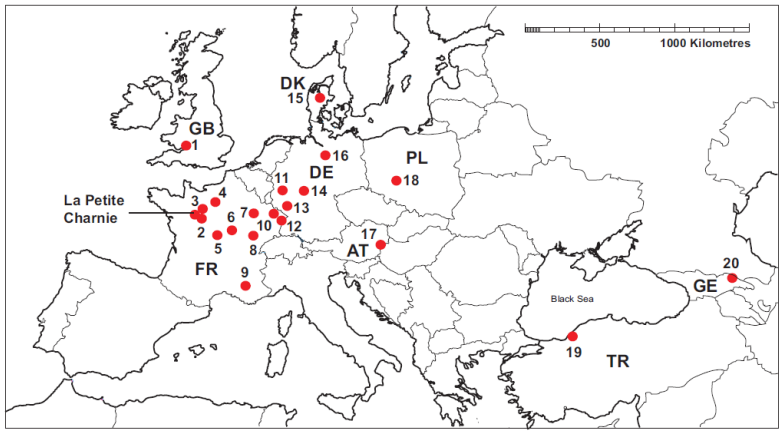
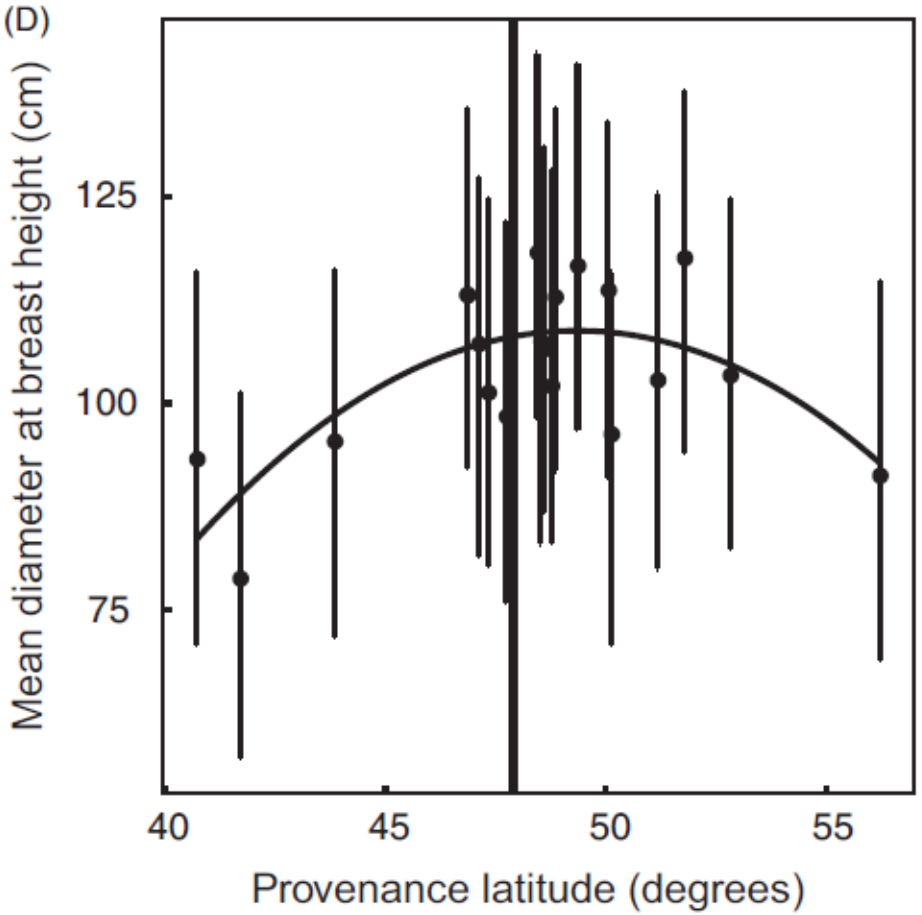
European beech
provenance trials



Robson et al. 2018 Scientific Data

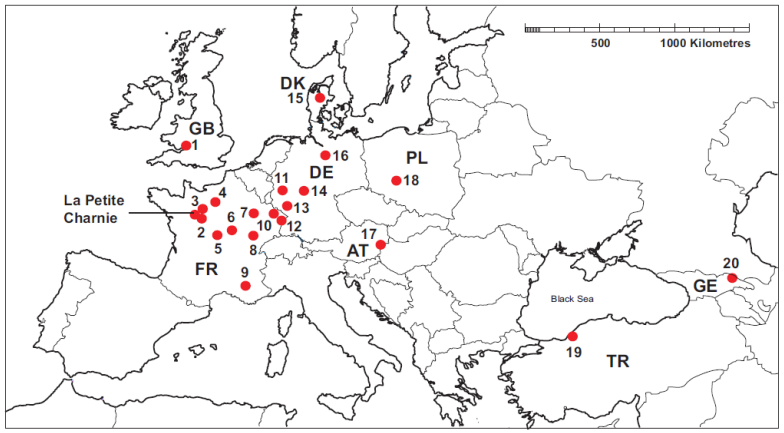
Adattamento genetico locale





Sinclair 2015 Evol Appl

Adattamento genetico locale



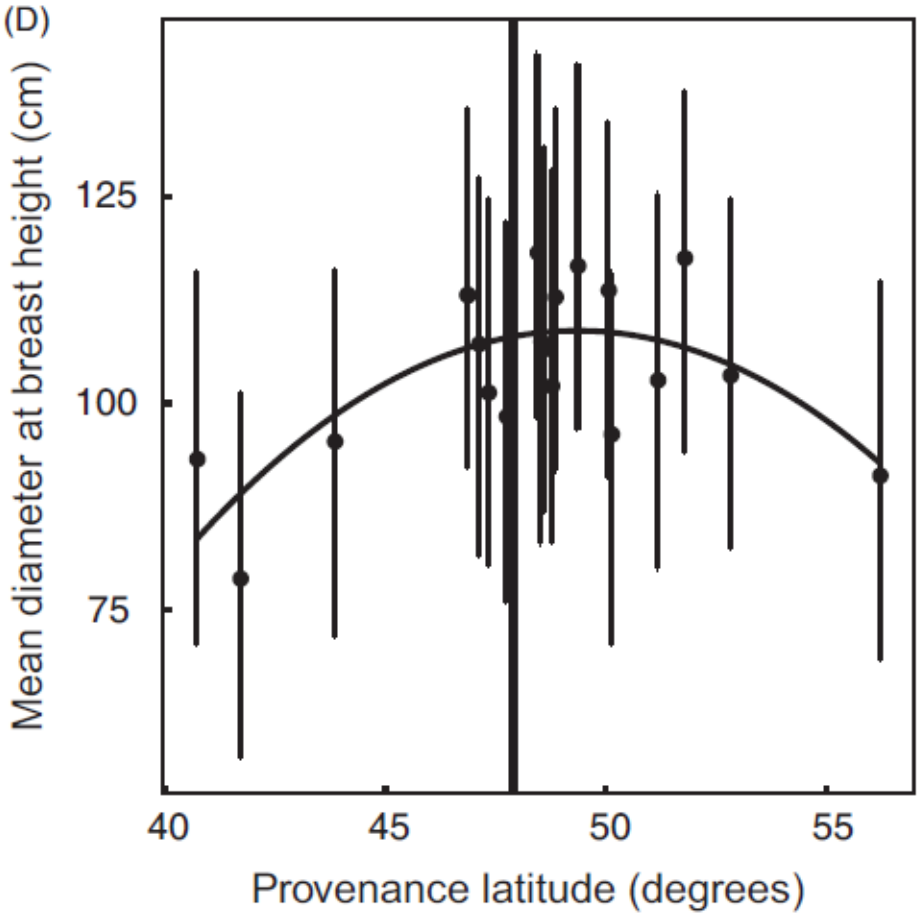
Global Change Biology

Global Change Biology (2013), doi: 10.1111/gcb.12181

REVIEW

Potential for evolutionary responses to climate change – evidence from tree populations

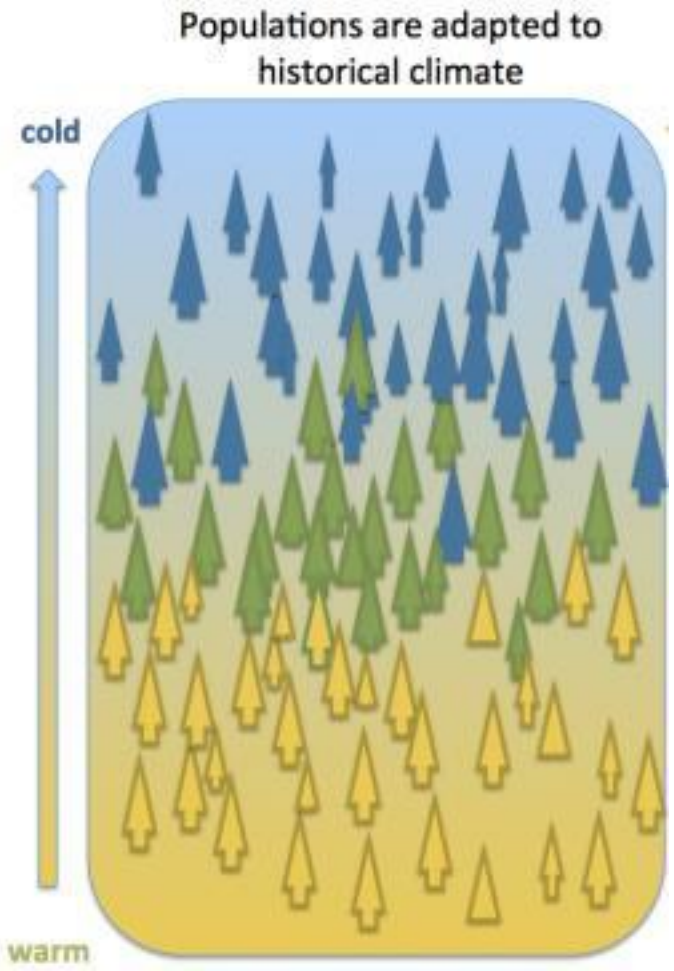
FLORIAN J. ALBERTO*†‡, SALLY N. AITKEN§, RICARDO ALÍA¶, SANTIAGO C. GONZÁLEZ-MARTÍNEZ¶, HEIKKI HÄNNINEN‖, ANTOINE KREMER†‡, FRANÇOIS LEFÈVRE**, THOMAS LENORMAND††, SAM YEAMAN§‡‡, ROSS WHETTEN§§ and OUTI SAVOLAINEN*



- Provenance trial
- 59 specie, 250 anni
- **Evidenze di adattamento locale in oltre l'80% dei casi**

Sinclair 2015 Evol Appl

Il clima sta cambiando…



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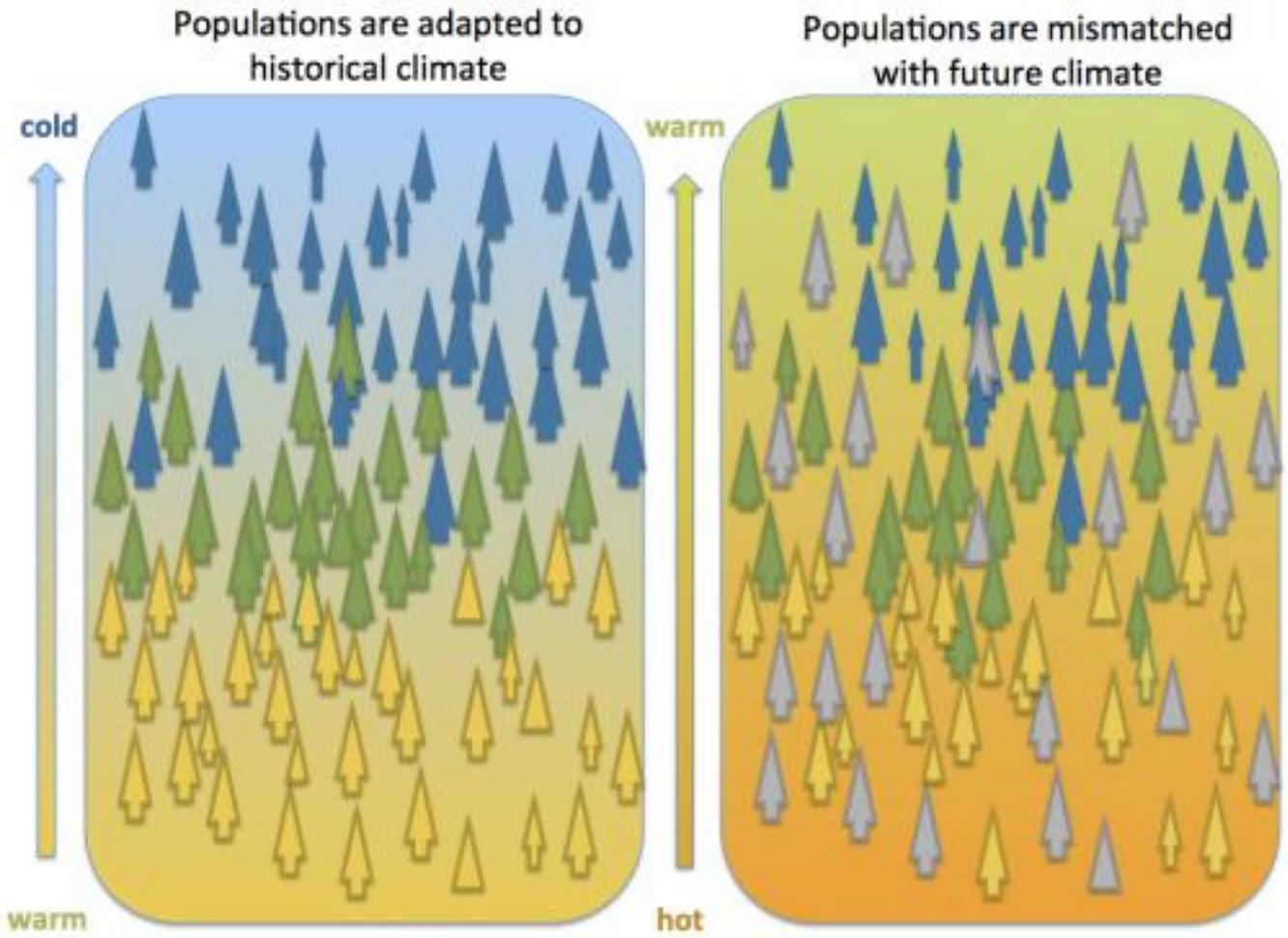


blogs.ubc.ca/aitkenlab/

…a una velocità insostenibile per le nostre foreste?

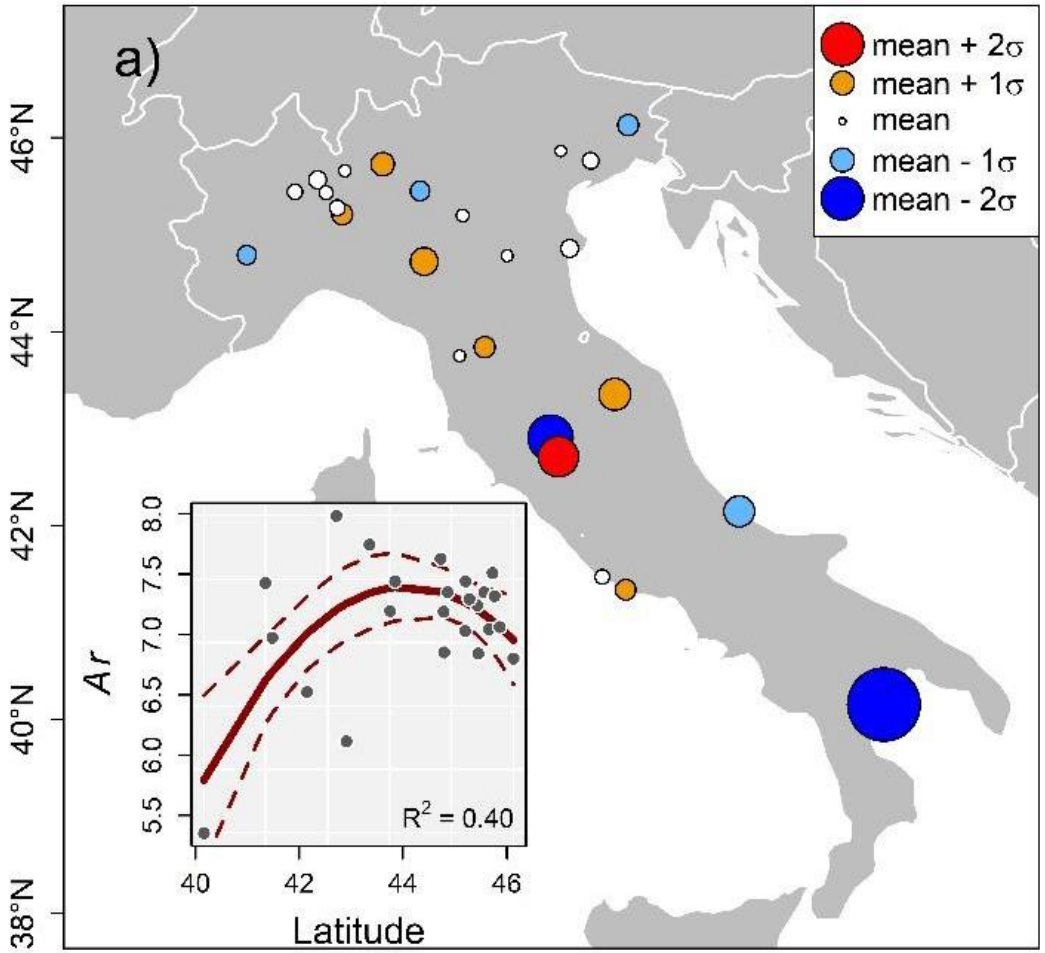
...e con il clima cambiano le dinamiche di adattamento locale

Picea sitchensis common garden
Vancouver (BC)
Aitken & Bemmels 2016 EvolAppl

The Modern Forest Blog: "*A picture is worth a thousand words*"

AdapTree

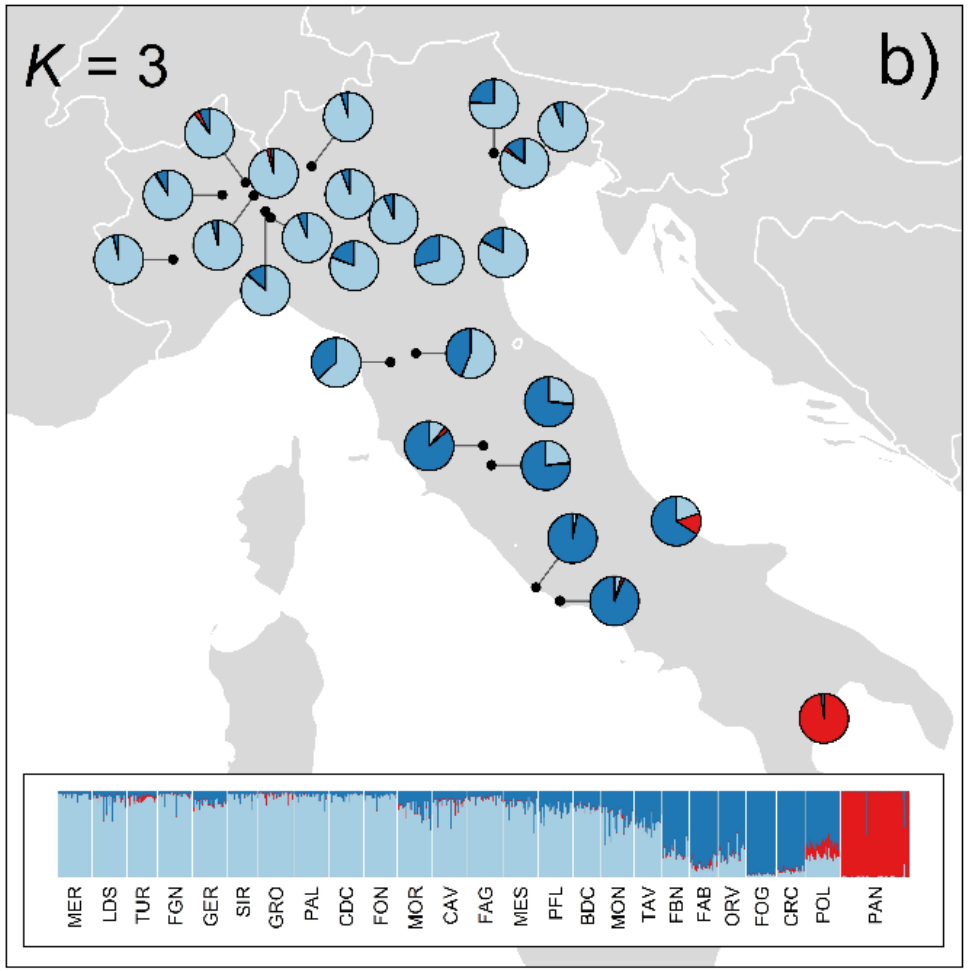
La diversità genetica non è distribuita omogeneamente nello spazio



Farnia

Avanzi et al. (2025) *Diversity and Distributions*

La diversità genetica non è strutturata omogeneamente nello spazio



Farnia

Avanzi et al. (2025) *Diversity and Distributions*

1 - Quanta diversità genetica c'è

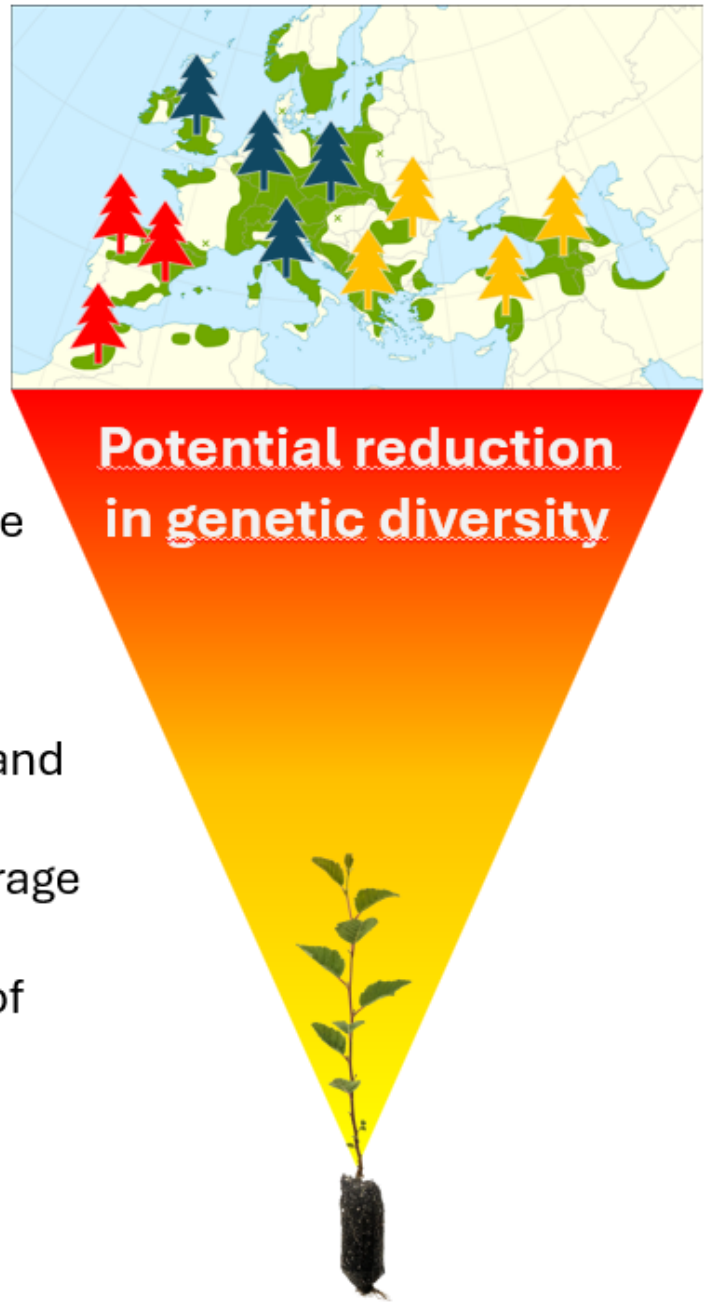
2 - Quale diversità genetica c'è

1 - Quanta diversità genetica c'è
2 - Quale diversità genetica c'è

La diversità genetica può essere influenza e controllata dalla filiera vivaistica

POSSIBILE CALO DELLA DIVERSITÀ GENETICA LUNGO LA FILIERA VIVAISTICA

FACTORS POTENTIALLY AFFECTING THE GENETIC DIVERSITY OF NURSERY MATERIAL



1. Number and location of source populations
2. Number of seed trees within selected populations
3. "Phenology" of seed ripening and seed collection
4. Seed processing, grading, storage and handling procedures
5. Germination and emergence of plantlets
6. Nursery cultivation practices
7. Final selection of forest reproductive material

PEN-CAFoRR

CA19128 - Pan-European Network for Climate Adaptive Forest Restoration and Reforestation

PEN-CAFoRR at COST Website

http://www.pen-caforr.org

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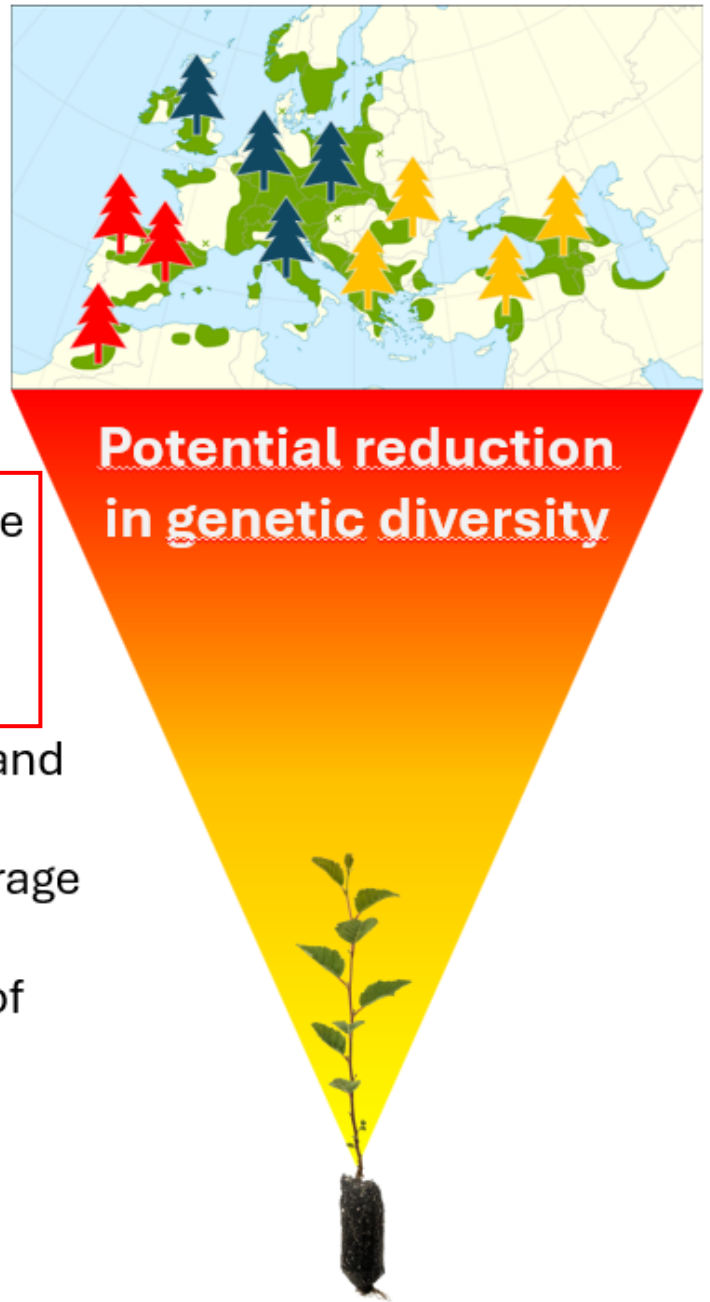

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PEN-CAFoRR at COST Website

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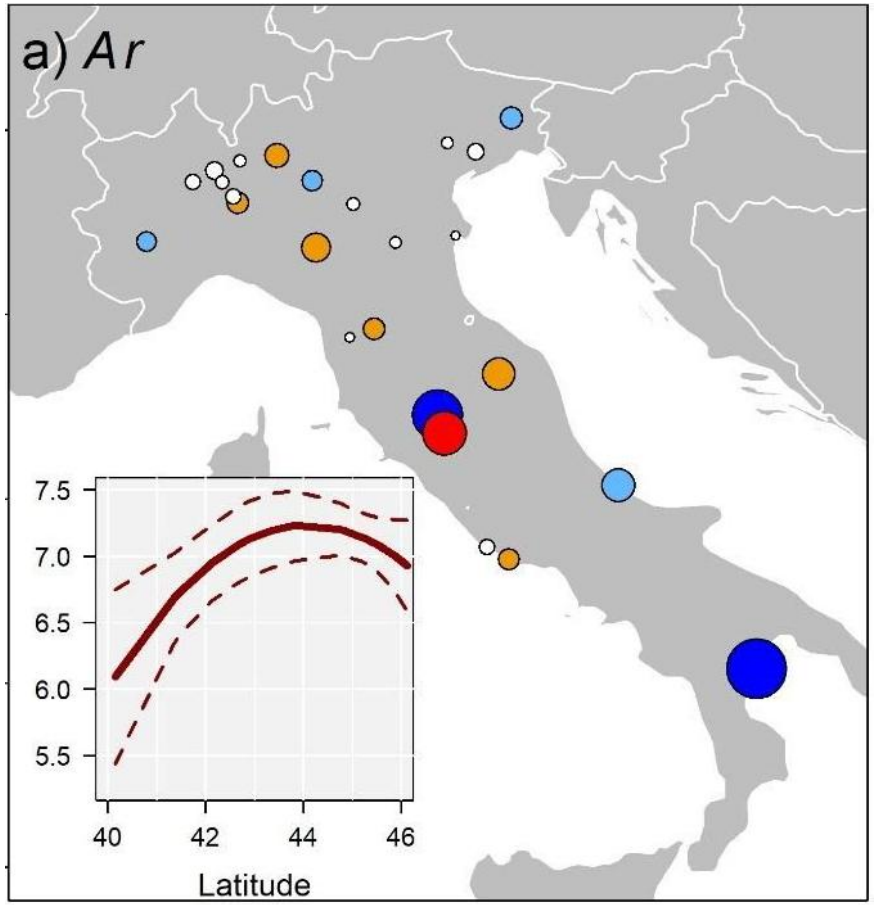
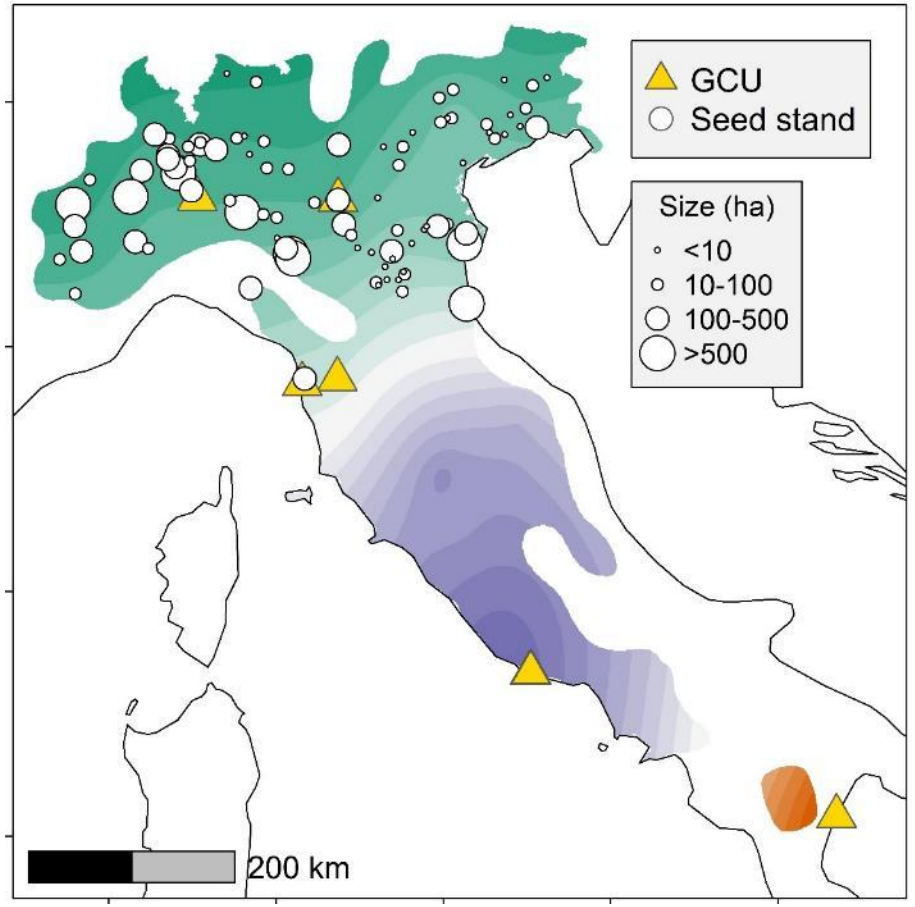
Scelta delle popolazioni di origine del seme

Ricchezza allelica



Struttura genetica



Farnia (*Quercus robur*)

Avanzi *et al*. (2025) *Diversity and Distributions*

https://www.politicheagricole.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/17198#mappa

Qual è la rappresentatività dei gruppi genetici presenti in Italia nella geografia dei materiali di base?

Governo Italiano

Ministero dell'agricoltura, della sovranità alimentare e delle foreste

Seguici su

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Ministero Notizie Politiche europee Politiche nazionali Controlli Qualità Ricerca PNRR

Home › Politiche nazionali › Foreste › Risorse genetiche forestali

Cartografia dei Materiali di Base pe
Moltiplicazione

In questa sezione sono disponibili le mappe relative alla localizzazione dei
(RNMB). Per ogni specie elencata nel menù a sinistra è possibile individua

Abies - Betula
Carpinus - Ostrya
Picea - Populus
Prunus - Quercus

link diretto alla mappa - Rob

Robinia pseudoacaci

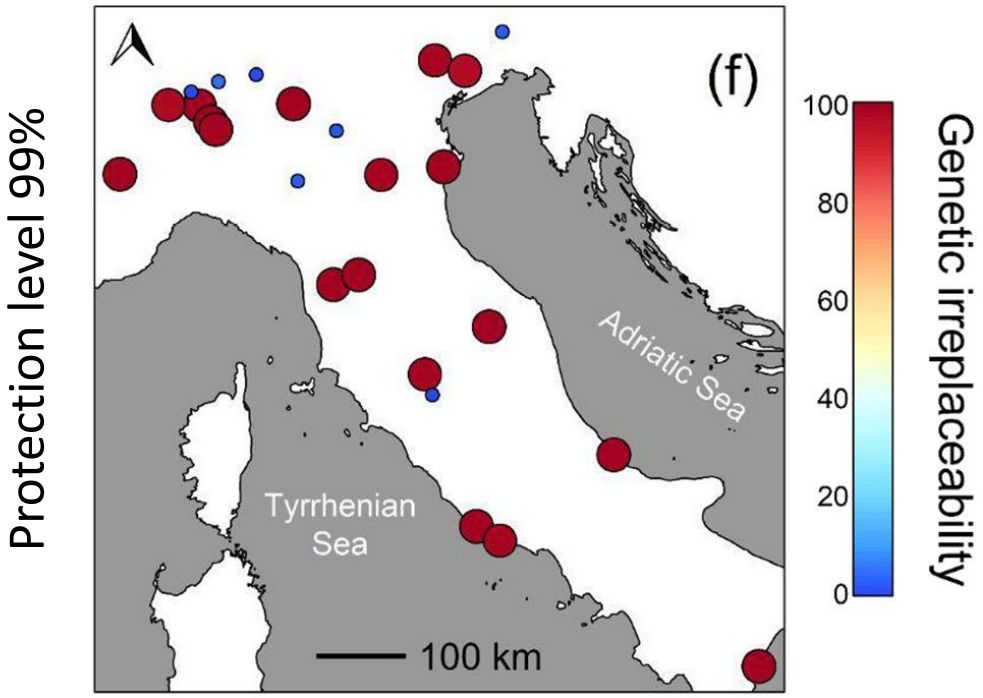
https://www.politicheagricole.it/flex/

Qual è la rappresentat
in Italia nella geog

Abete bianco

4 gruppi genetici (Piotti et al. 2017 J Biog):
3 sono rappresentati

Ottimizzare il network dei boschi da seme?



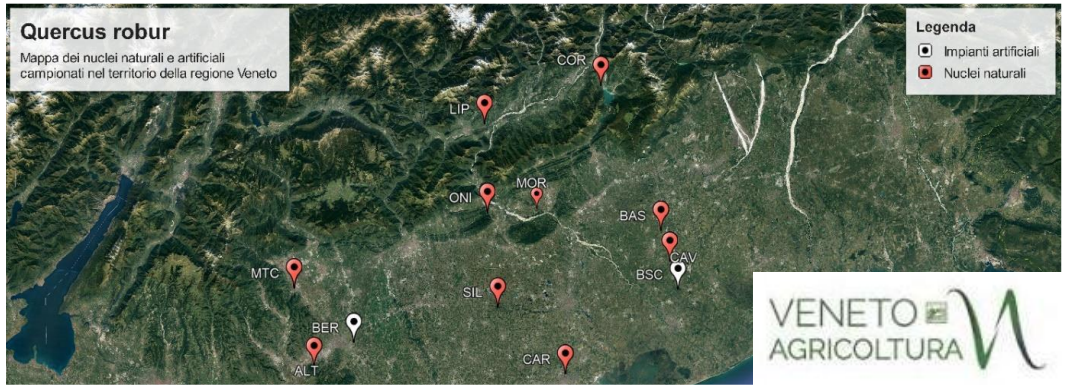
Contents lists available at ScienceDirect
Biological Conservation
journal homepage: www.elsevier.com/locate/biocon

Spatial conservation planning of forest genetic resources in a Mediterranean multi-refugial area

Elia Vajana [a,*], Marco Andrello [b], Camilla Avanzi [a], Francesca Bagnoli [a], Giovanni G. Vendramin [a], Andrea Piotti [a]

- Utilizzo algoritmi di **Spatial Conservation Prioritization** (SCP)
- ~70% delle popolazioni indagate vengono segnalate come **insostituibili** per la conservazione del 99% della diversità genetica
- La frequenza delle popolazioni indispensabili cresce nelle **aree rifugio**

Scelta dei boschi da cui raccogliere i semi



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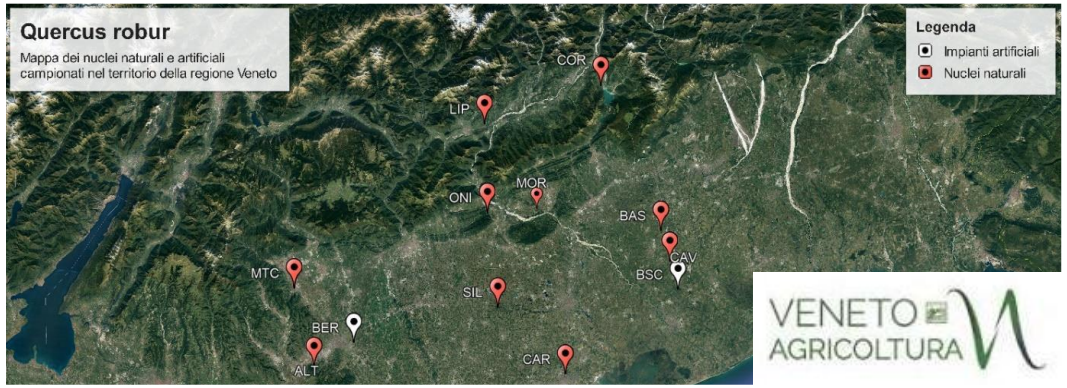
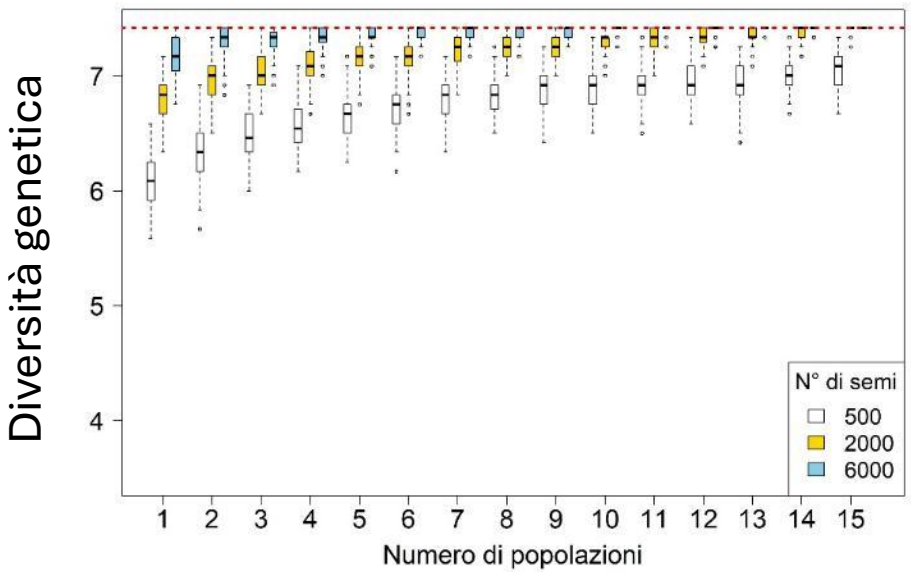
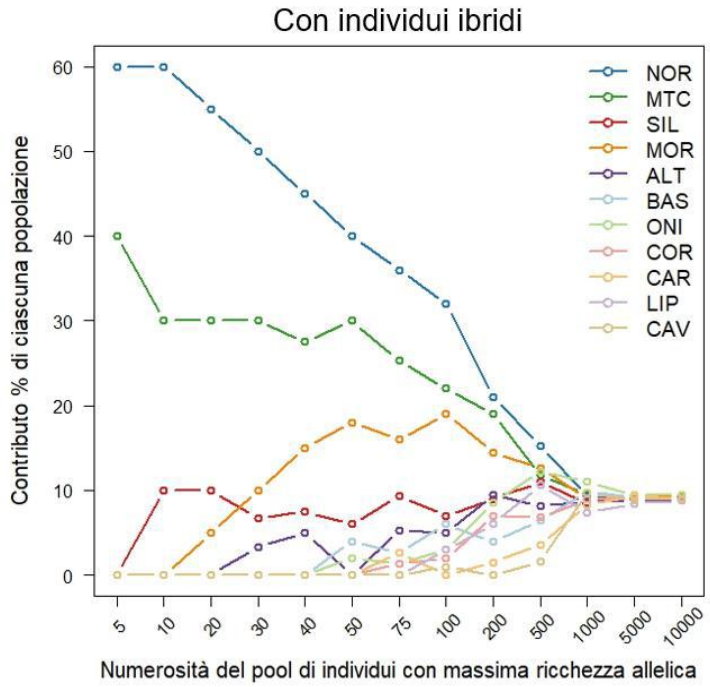


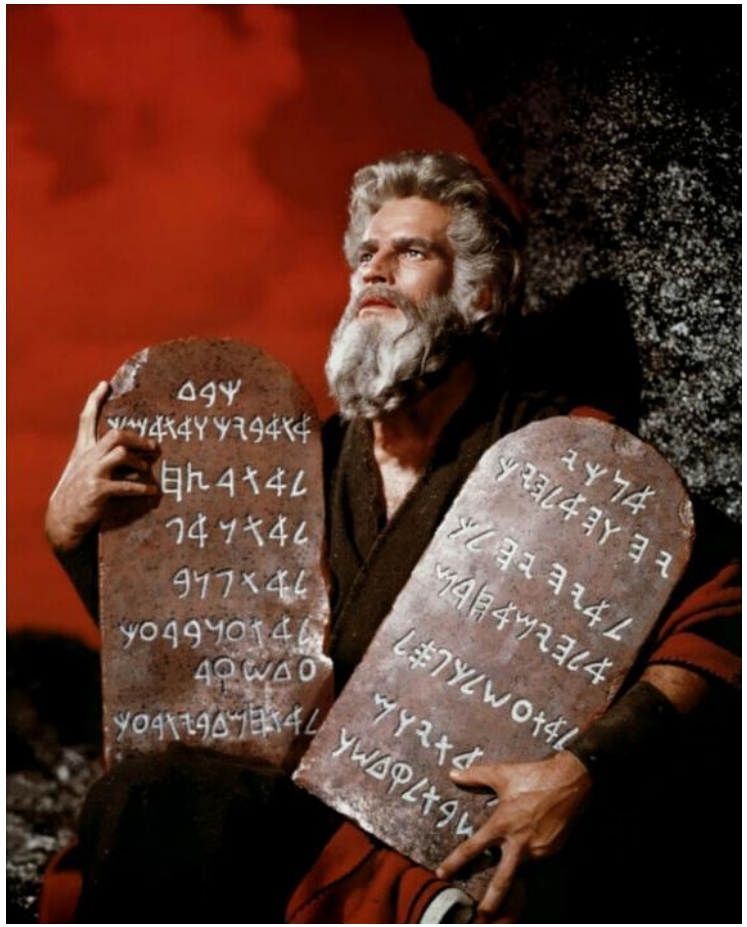
SIMULAZIONI





Scelta degli alberi da cui raccogliere i semi

Scelta degli alberi da cui raccogliere i semi



Raccolta da ≥20 alberi distanziati ≥30 m

Check for updates

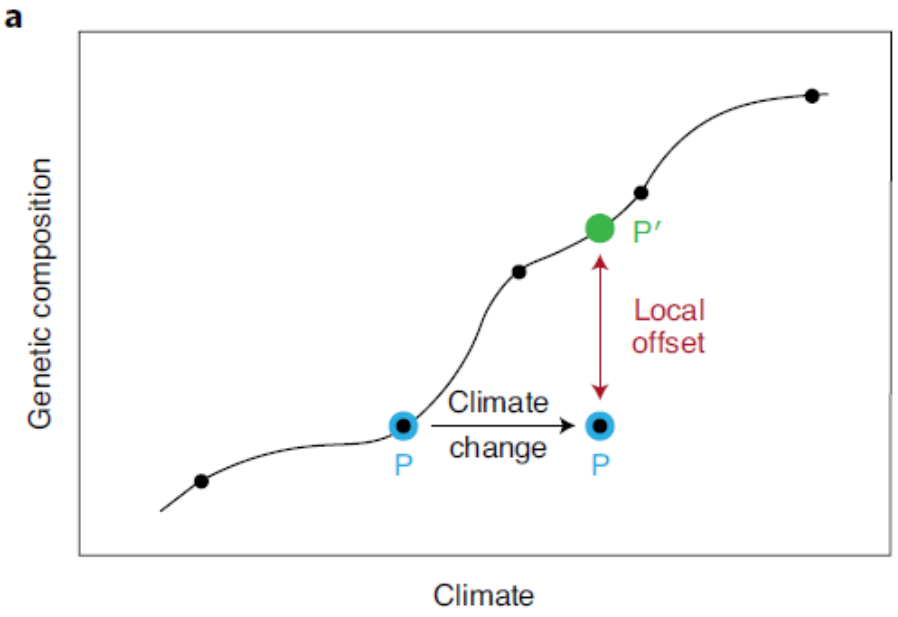
news & views

PREDICTIVE GENOMICS

Genomics helps to predict maladaptation to climate change

The combination of highly resolved climatic and genomic data allows assessment of putative maladaptation of populations to climate change and can identify high-risk populations. Now, a study that accounts for migration and dispersal shows high maladaptation of a North American tree species in the northern and eastern distribution range.

Christian Rellstab



*"One recently developed and popular approach to predict such putative genetic maladaptation to future conditions is **genetic offset**, also called genomic vulnerability or risk of non-adaptedness.*

Based on a statistical relationship between contemporary genomic and environmental data, it predicts the genetic distance of a specific population today to its theoretically required genetic composition under possible future conditions"

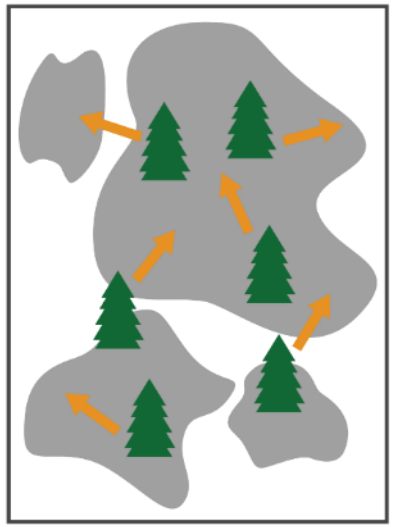
Assisted migration (o come la vogliamo chiamare…😲)

Evolutionary Applications
Open Access
Evolutionary Applications ISSN 1752-4571

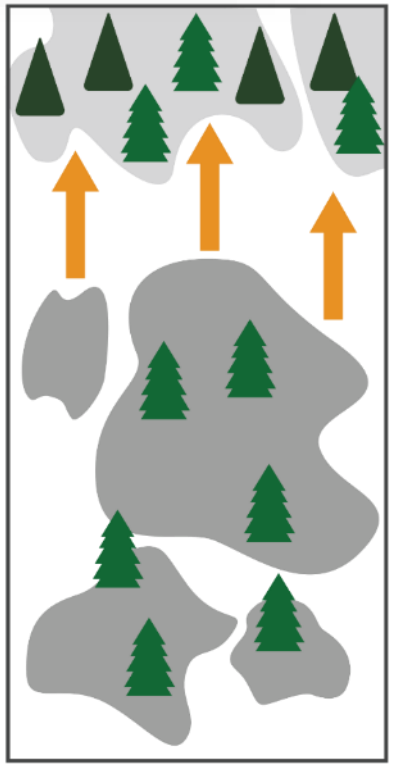
REVIEW AND SYNTHESES

Time to get moving: assisted gene flow of forest trees

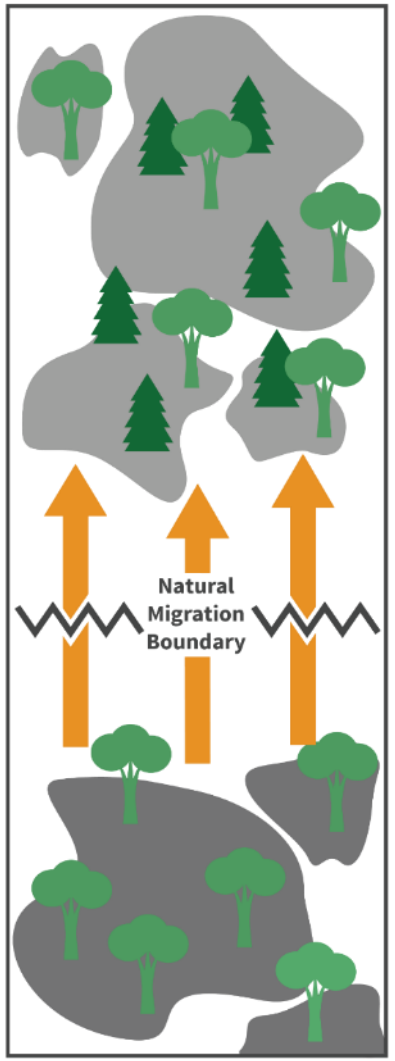
Sally N. Aitken[1] and Jordan B. Bemmels[2]



Assisted Population Migration



Assisted Range Expansion



Assisted Species Migration

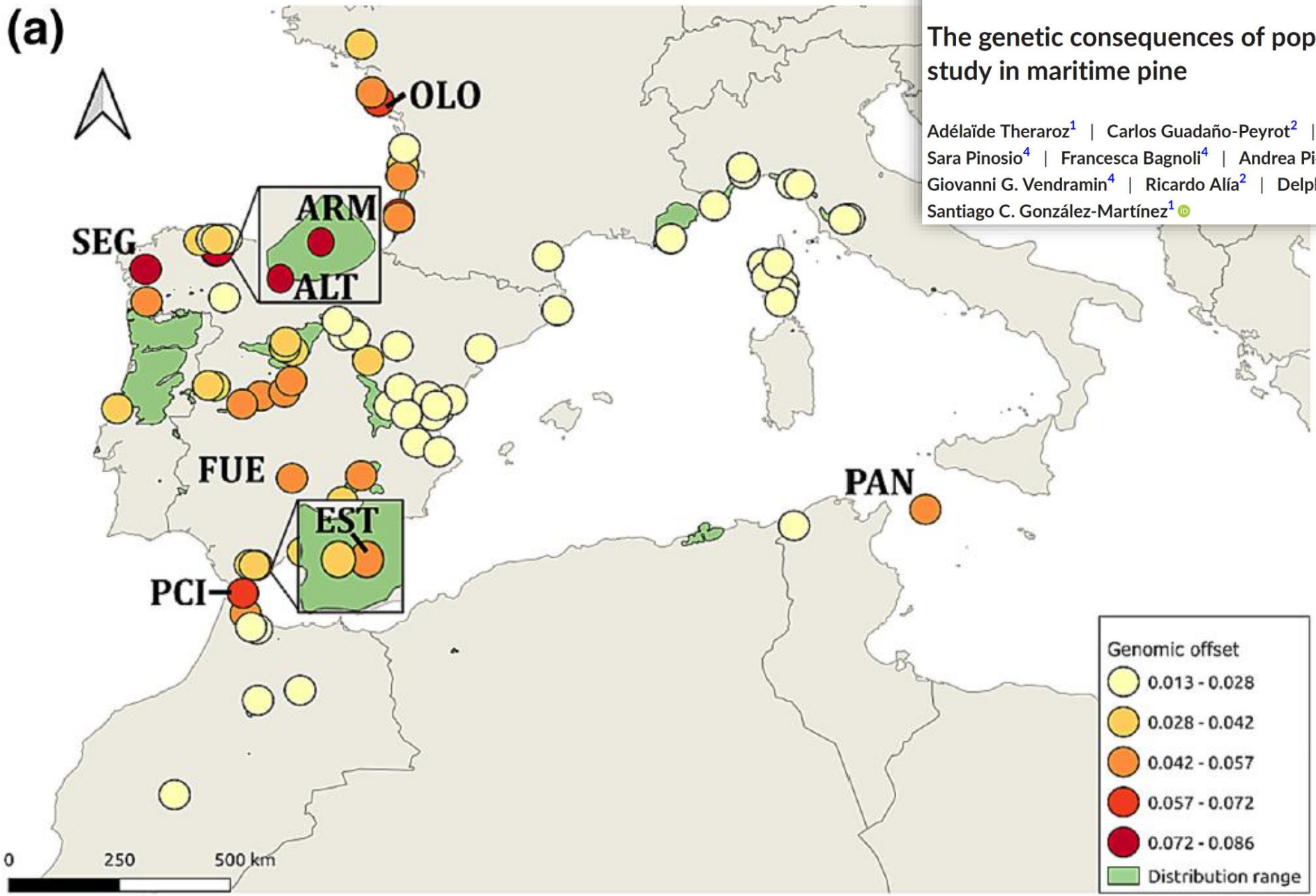
USDA Forest Service

RESEARCH ARTICLE

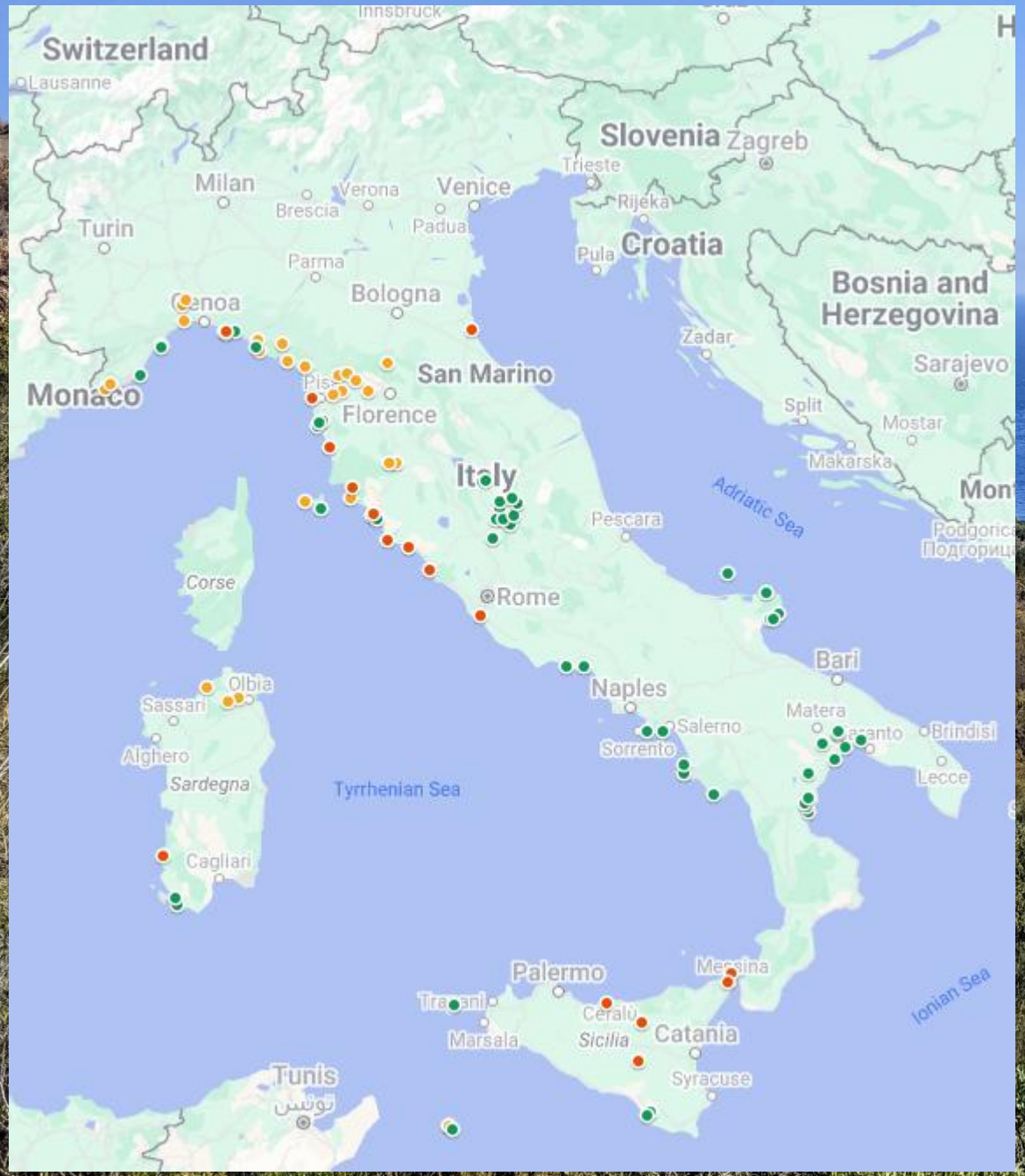
Diversity and Distributions WILEY

The genetic consequences of population marginality: A case study in maritime pine

Adélaïde Theraroz[1] | Carlos Guadaño-Peyrot[2] | Juliette Archambeau[1,3] | Sara Pinosio[4] | Francesca Bagnoli[4] | Andrea Piotti[4] | Camilla Avanzi[4] | Giovanni G. Vendramin[4] | Ricardo Alía[2] | Delphine Grivet[2] | Marjana Westergren[5] | Santiago C. González-Martínez[1]




MedForAct
https://sites.google.com/view/medforact



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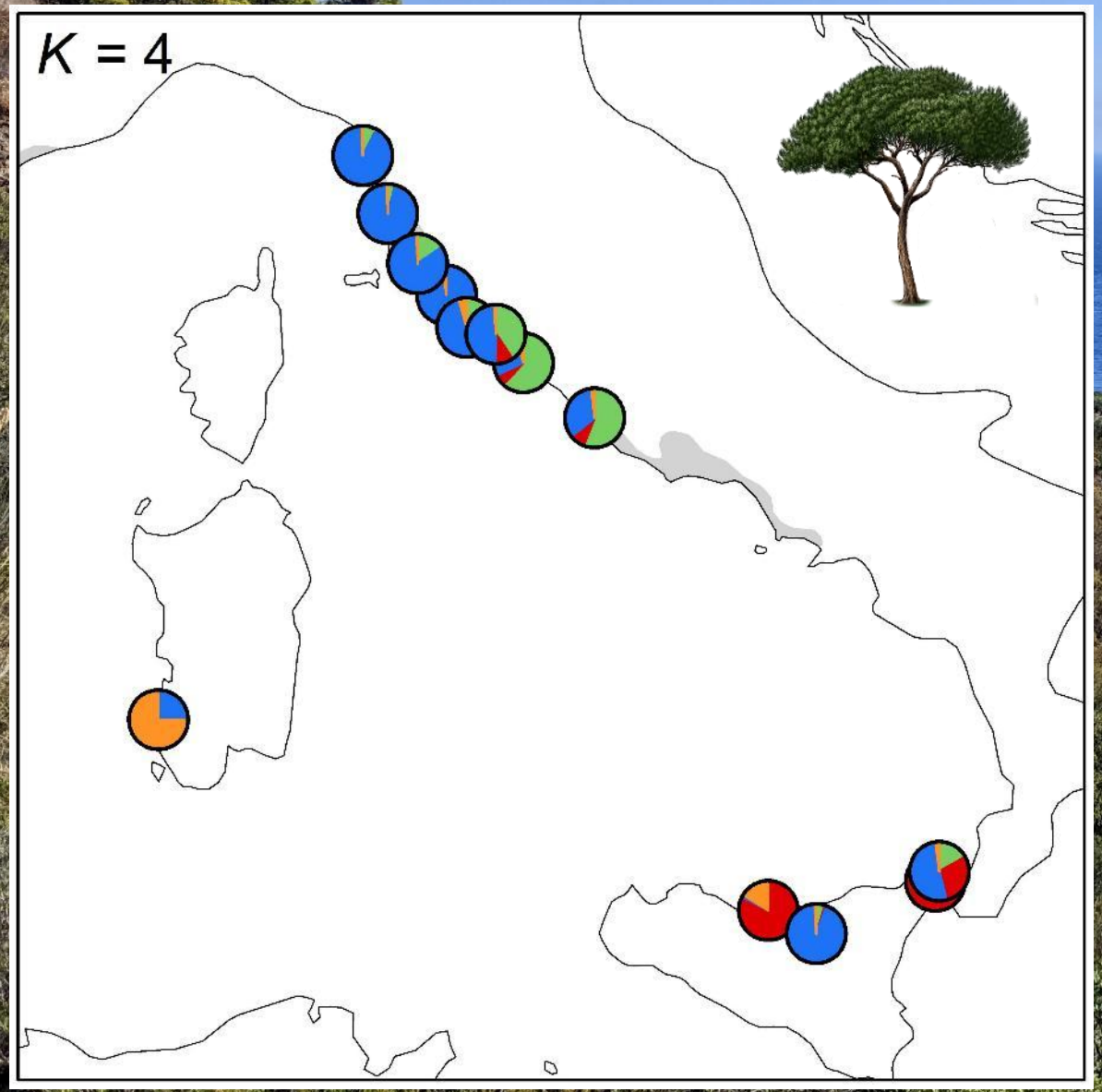
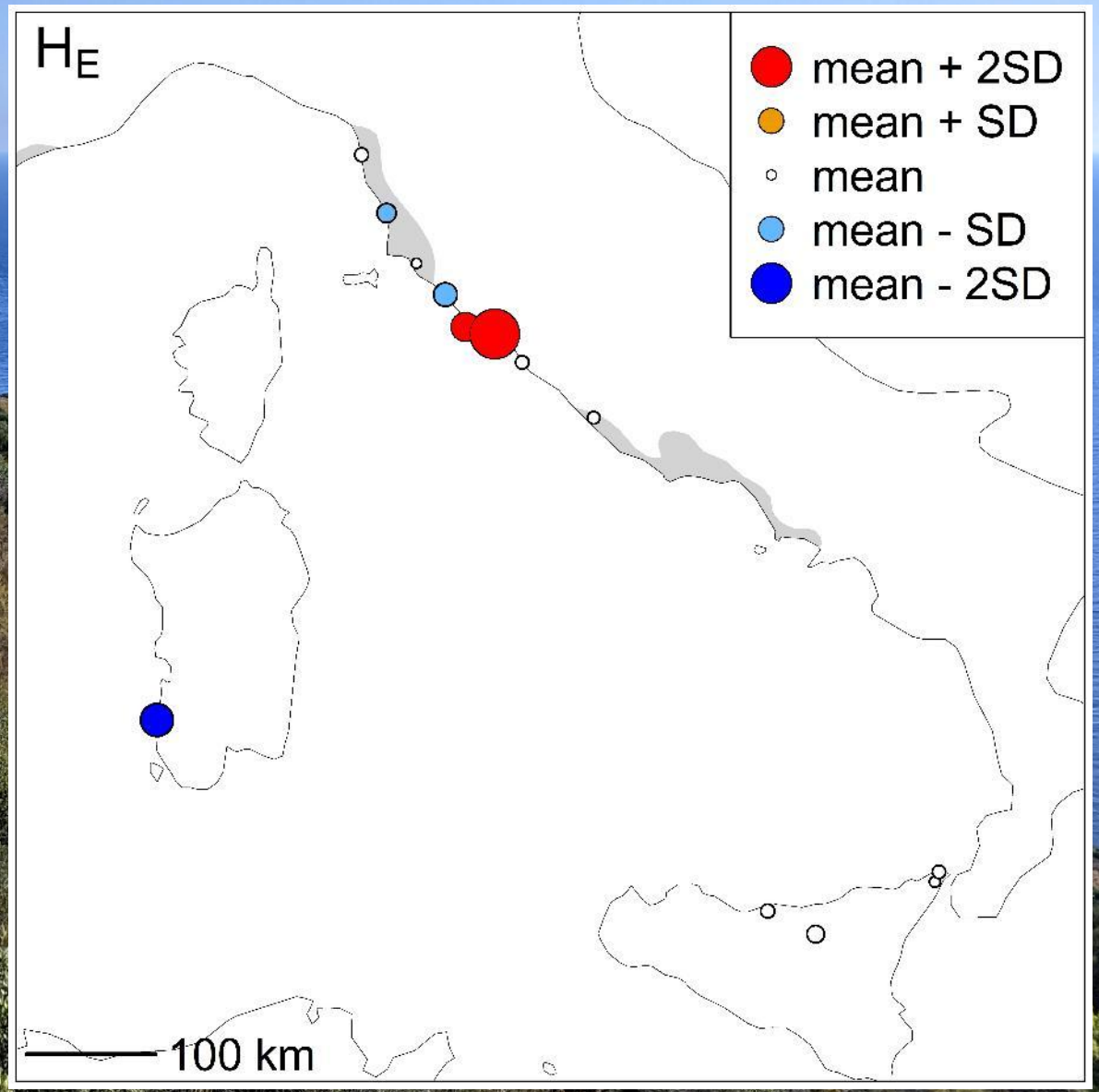
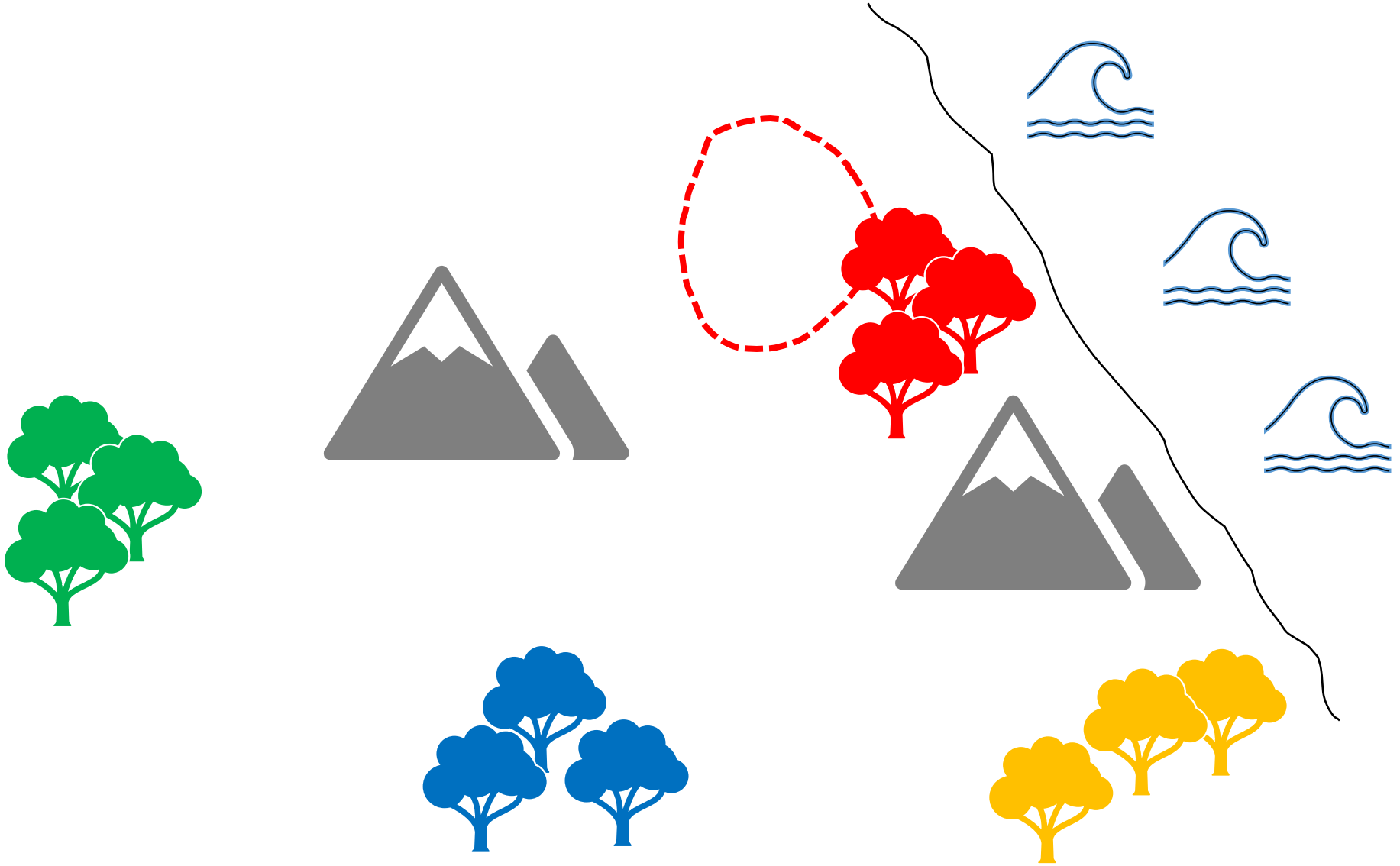
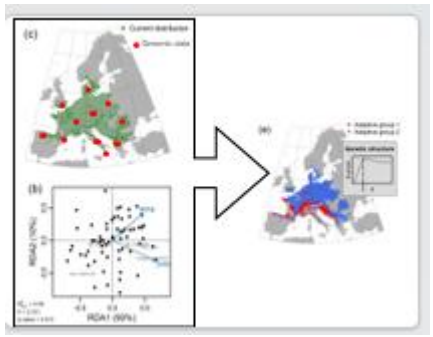


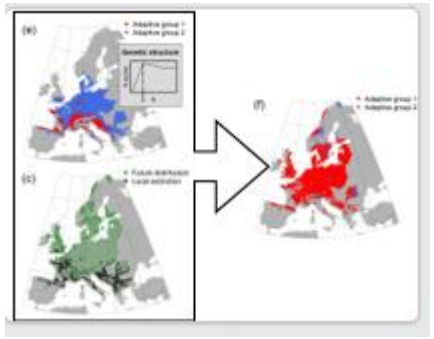


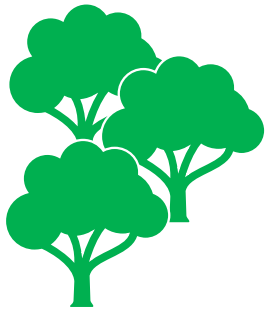
Applicazioni?

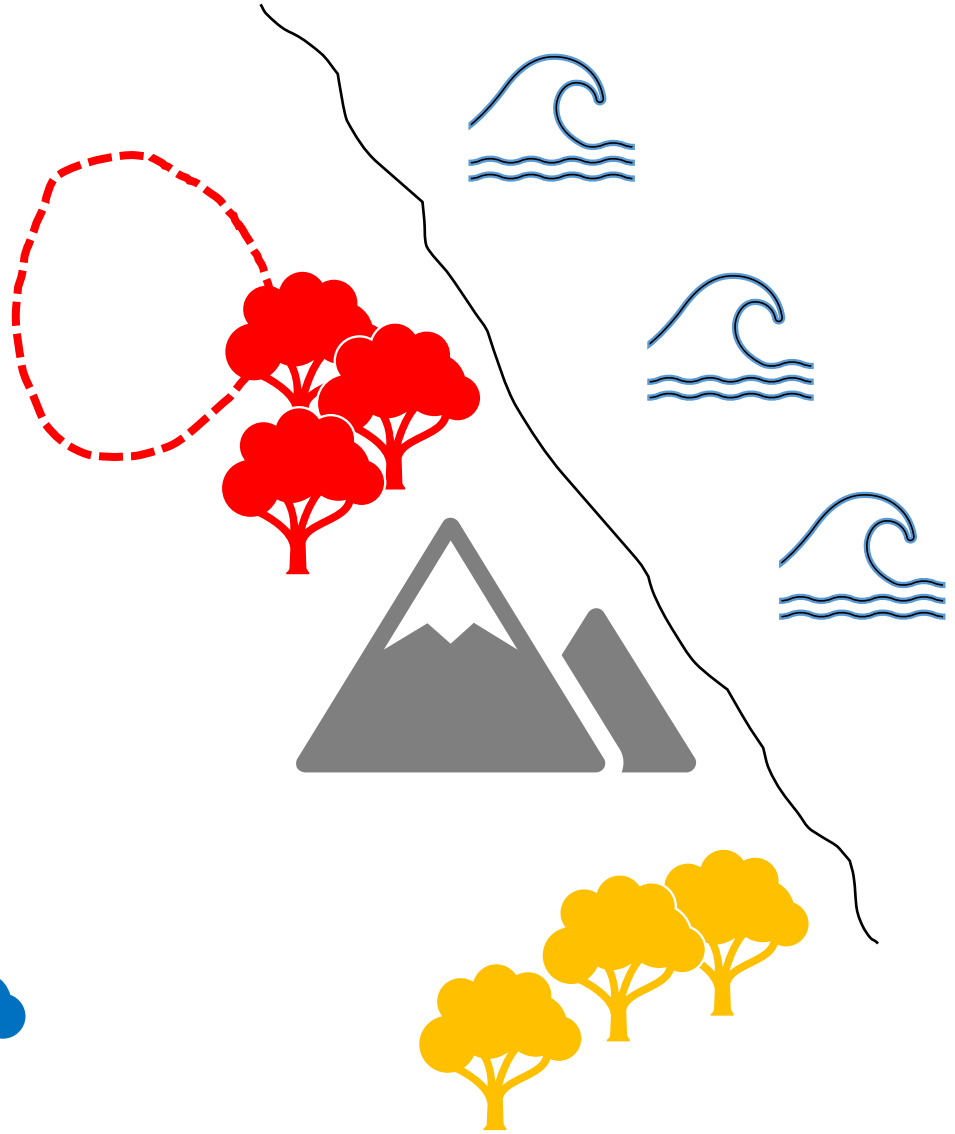


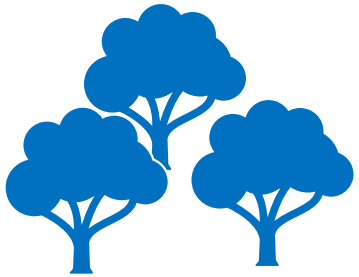
Applicazioni?







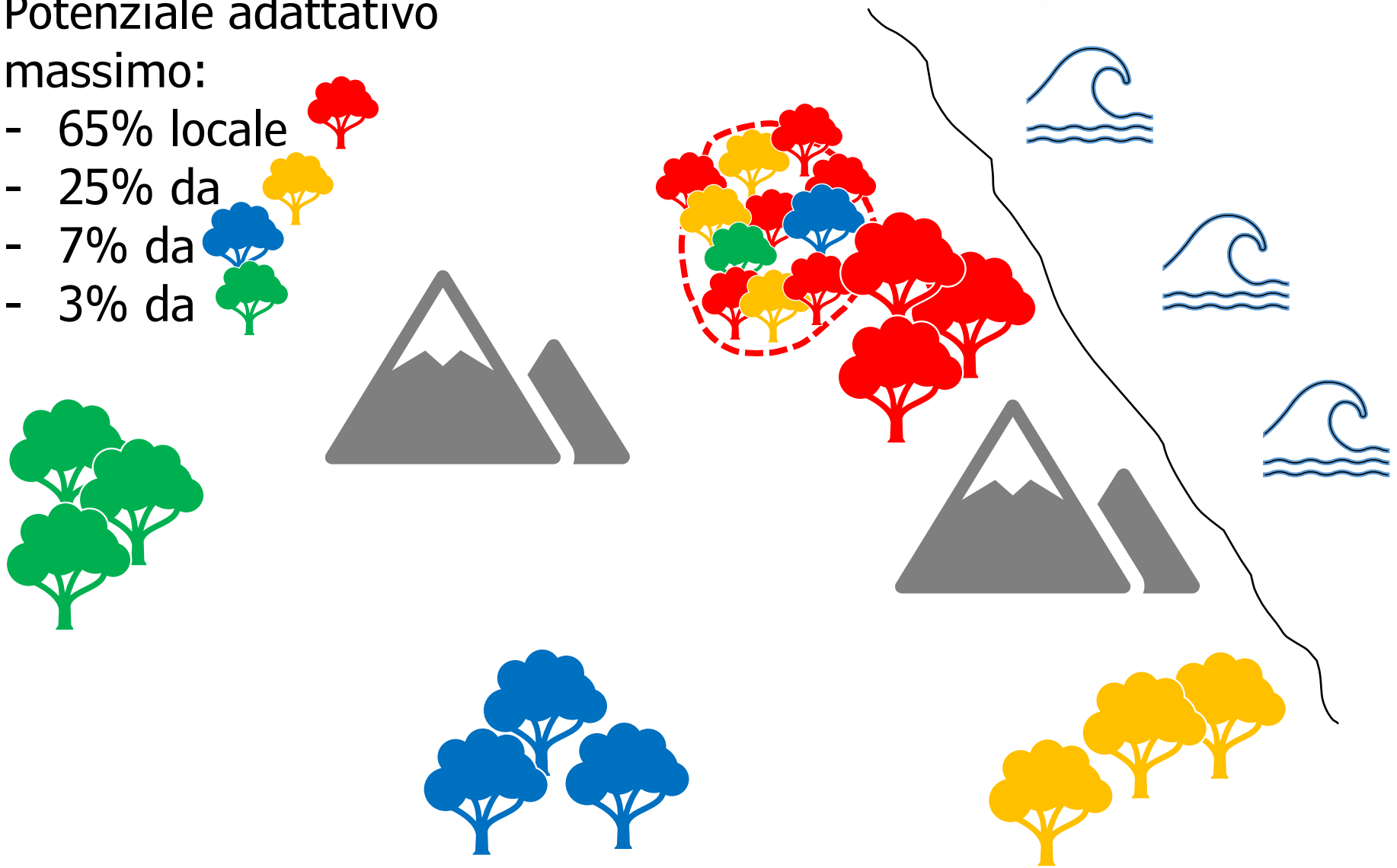




Applicazioni!

Potenziale adattativo massimo:

- 65% locale
- 25% da
- 7% da
- 3% da



Applicazioni!

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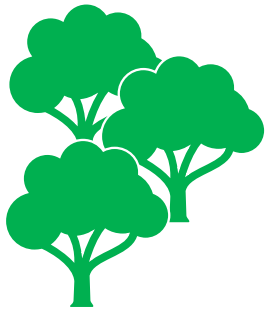
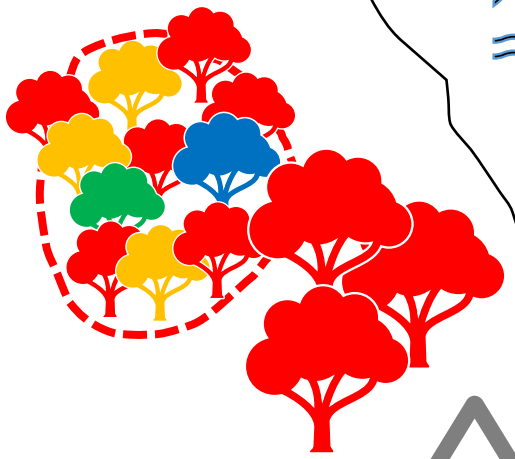
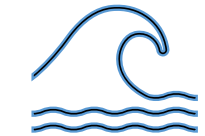
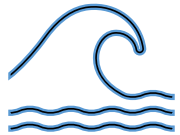
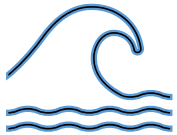
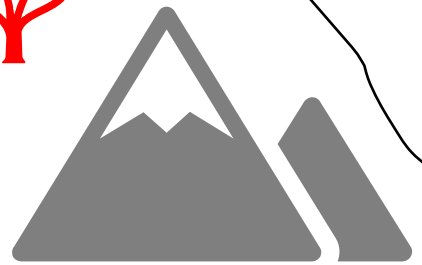




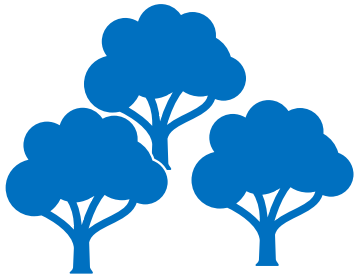








Boschi da seme
Riserve Biogenetiche
Genetic Conservation Unit
Filiera vivaistica
Milioni di nuovi alberi



VIEWPOINT

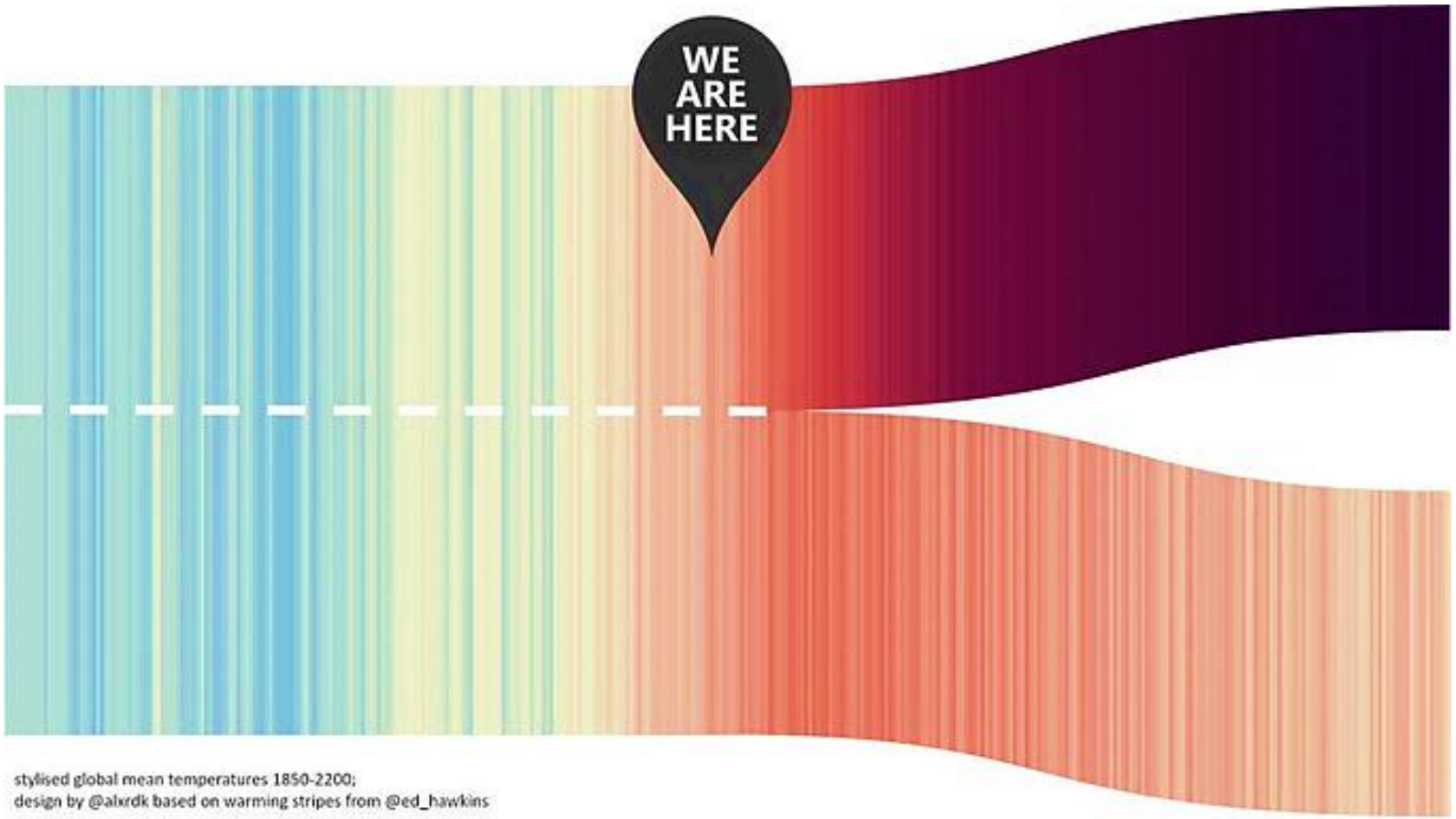
ECOLOGY LETTERS cnrs WILEY

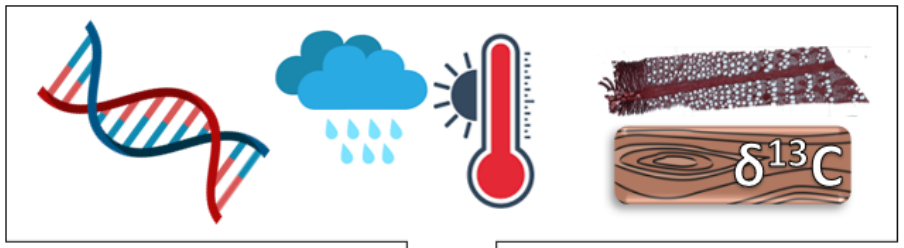
The eco-evolutionary risks of not changing seed provenancing practices in changing environments

Rebecca Jordan[1] | Peter A. Harrison[2] | Martin Breed[3]

Non suggeriamo che i semi di provenienze locali non debbano più essere utilizzato quando è opportuno farlo.
Piuttosto, incoraggiamo un ***approccio ponderato*** *in cui i rischi di di fare questa scelta siano soppesati rispetto al rischio di utilizzare provenieze non locali.*

Siamo a un bivio





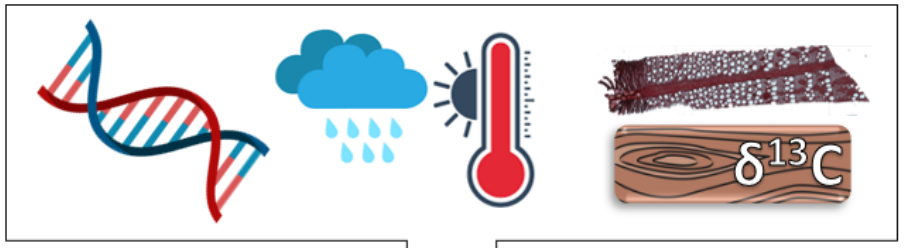
How could I restore this area?

Informed selection of provenances

Random selection of provenances

GENTREE FORGENIUS Best OptFORESTS NATIONAL BIODIVERSITY FUTURE CENTER AGRITECH RI-VIVA-FOR Manifesto per il rilancio delle attività vivaistiche in Italia AlberItalia SISEF Regione Lombardia Progetto Res Parco Nazionale APPENNINO TOSCO EMILIANO MigAss

Primi dati genomici utili



How could I restore this area?

Informed selection of provenances

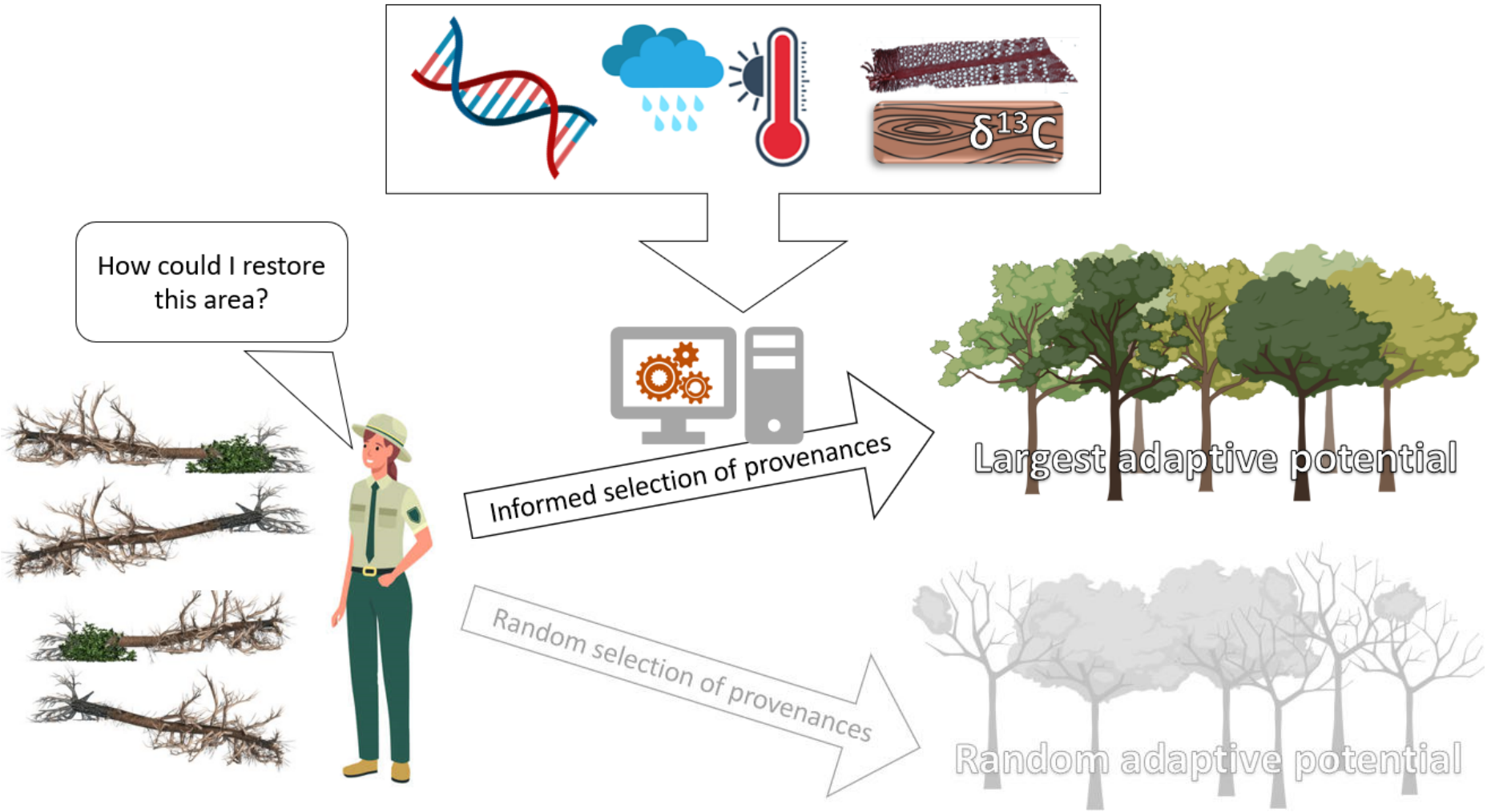
Random selection of provenances

Grazie per l'attenzione!

Per richieste, idee, domande:

andrea.piotti@cnr.it

https://sites.google.com/site/andreapiotti/



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